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THE PRESENT POSITION AND FUTURE PROSPECTS OF THE CHEMICAL INDUSTRY IN GREAT BRITAIN[1]

FOR the third time in succession the Section meets under the shadow of the war cloud, but there is some slight consolation for the indescribable suffering and sorrow which have been imposed upon millions of our fellow creatures in the hope and belief that this cloud also may have a silver lining. It is perhaps no exaggeration to say that nothing less than such an upheaval of existing habits and traditions as has been caused by the war would have sufficed to arouse the British nation from the state of apathy towards science with which it has been fatuously contented in the past. Now, however, the sleeper has at least stirred in his slumber. The press bears witness, through the appearance of innumerable articles and letters, that the people of this country, and even the politicians, have begun to perceive the dangers which will inevitably result from a continuance of their former attitude, and to understand that in peace, as in war, civilization is at a tremendous disadvantage in the struggle for existence unless armed by science, and that the future prosperity of the empire is ultimately dependent upon the progress of science, and very specially of chemistry. If, as one result of the war, our people are led to appreciate the value of scientific work, then perhaps we shall not have paid too high a price, high although the price must be. As concerns our own branch of science,

[1] Address before the Chemical Section of the British Association for the Advancement of Science, Newcastle-on-Tyne, 1916.

we can not rest satisfied with anything less than full recognition of the fact that chemistry is a profession of fundamental importance, and that the chemist is entitled to a position in no respect inferior to that of a member of any of the other learned professions.

Reference to the annual reports of the association shows that former presidents of the Section have availed themselves to the full of the latitude permitted in the choice of a subject for their address, and that some have even established the precedent of dispensing with an address altogether. On the present occasion a topic for discussion seems to be clearly indicated by the circumstances in which we stand, because, since the outbreak of the war, chemists have been giving more earnest consideration than before to the present position and future prospects of the chemical industry of this country. It will, therefore, not be inappropriate if I touch upon some aspects of this question, even although unable to add much to what is, or ought to be, common knowledge.

The period which has elapsed since the last meeting of the Section in Newcastle has witnessed truly remarkable progress in every branch of pure and applied chemistry. For fully fifty years previous to that meeting the attention of the great majority of chemists had been devoted to organic chemistry, but since 1885 or thereabouts, whilst the study of the compounds of carbon has been pursued with unflagging energy and success, it has no longer so largely monopolized the activities of investigators. Interest in the other elements, which had been to some extent neglected on account of the fascinations of carbon, has been revived with the happiest results, for not only has our knowledge of these elements been greatly extended, but their number also has been notably increased by the discovery of two groups of simple substances possessed of new and remarkable properties—the inert gases of the argon family and the radio-active elements. In addition, the bonds between mathematics and physics, on the one hand, and chemistry, on the other, have been drawn closer, with the effect that the department of our science known as physical chemistry has now assumed a position of first-rate importance. With the additional light provided by the development and application of physico-chemical theory and methods, we are beginning to gain some insight into such intricate problems as the relation between physical properties and chemical constitution, the structure of molecules and even of atoms, and the mechanics of chemical change; our outlook is being widened, and our conceptions rendered more precise. Striking advances have also been made in other directions. The extremely difficult problems which confront the bio-chemist are being gradually overcome, thanks to the indefatigable labors of a band of highly skilled observers, and the department of biological chemistry has been established on a firm footing through the encouraging results obtained within the period under review. Further, within the last few years many of our ideas have been subjected to a revolutionary change through the study of the radio-active elements, those elusive substances which occur in such tantalizingly minute quantities, and of which some appear so reluctant to exist in a free and independent state that they merge their identity in that of another and less retiring relative within an interval of time measured by seconds. In truth, if a Rip Van Winkle among chemists were to awake now after a slumber of thirty years, his amazement on coming into contact with the chemistry of to-day would be beyond words.

The more purely scientific side of our science can claim no monopoly in progress, for applied chemistry, in every department,

has likewise advanced with giant strides, mainly of course through the application of the results of scientific research to industrial purposes. An attempt to sketch in the merest outline the recent development of applied chemistry would, I fear, exhaust your patience, but I may indicate in passing some of the main lines of advance. Many of the more striking results in the field of modern chemical industry have been obtained by taking advantage of the powers we now possess to carry out operations economically, both at very high and at very low temperatures, and by the employment on the manufacturing scale of electrolytic and catalytic methods of production. Thanks largely to the invention of the dynamo, the technologist is now able to utilize electrical energy both for the production of high temperatures in the different types of electric furnace and for electrolytic processes of the most varied description. Among the operations carried out with the help of the electric furnace may be mentioned the manufacture of graphite, silicon and phosphorus; of chromium and other metals; of carbides, silicides and nitrides, and the smelting and refining of iron and steel. Calcium carbide claims a prominent place in the list, in the first place because of the ease with which it yields acetylene, which is not only used as an illuminant, and, in the oxy-acetylene burner, as a means of producing a temperature so high that the cutting and welding of steel is now a comparatively simple matter, but also promises to serve as the starting-point for the industrial synthesis of acetaldehyde and many other valuable organic compounds. Moreover, calcium carbide is readily converted in the electric furnace into calcium cyanamide, which is employed as an efficient fertilizer in place of sodium nitrate or ammonium sulphate, and as a source of ammonia and of alkali cyanides. Among the silicides carborundum is increasingly used as an abrasive and a refractory material, and calcium silicide, which is now a commercial product, forms a constituent of some blasting explosives. The Serpek process for the preparation of alumina and ammonia, by the formation of aluminium nitride from beauxite in the electric furnace and its subsequent decomposition by caustic soda, should also be mentioned. Further, the electric furnace has made possible the manufacture of silica apparatus of all kinds, both for the laboratory and the works, and of alundum ware, also used for operations at high temperature. Finally, the first step in the manufacture of nitric acid and of nitrites from air, now in operation on a very large scale, is the combustion of nitrogen in the electric arc.

In other industrial operations the high temperature which is necessary is obtained by the help of the oxy-hydrogen or the oxy-acetylene flame, the former being used, amongst other purposes, in a small but I believe profitable industry, the manufacture of synthetic rubies, sapphires and spinels. Also, within a comparatively recent period, advantage has been taken of the characteristic properties of aluminium, now obtainable at a moderate price, in the various operations classed under the heading alumino-thermy, the most important being the reduction of refractory metallic oxides, although, of course, thermite is useful for the production of high temperatures locally.

The modern methods of liquefying gases, which have been developed within the period under review, have rendered possible research work of absorbing interest on the effect of very low temperatures on the properties and chemical activity of many substances, and have been applied, for instance, in separating from one another the members of the argon family, and in obtaining ozone in a state of prac-

tical purity. Moreover, industrial applications of these methods are not lacking, amongst which I may mention the separation of nitrogen and oxygen from air, and of hydrogen from water-gas—processes which have helped to make these elements available for economic use on the large scale.

Electrolytic methods are now extensively employed in the manufacture of both inorganic and organic substances, and older processes are being displaced by these modern rivals in steadily increasing number. It is sufficient to refer to the preparation of sodium, magnesium, calcium and aluminum, by electrolysis of fused compounds of these metals; the refining of iron, copper, silver and gold; the extraction of gold and nickel from solution; the recovery of tin from waste tin-plate; the preparation of caustic alkalies (and simultaneously of chlorine), of hypochlorites, chlorates and perchlorates, of hydrosulphites, of permanganates and ferricyanides, of persulphates and percarbonates; the regeneration of chromic acid from chromium salts; the preparation of hydrogen and oxygen. As regards organic compounds, we find chiefly in use electrolytic methods of reduction which are specially effective in the case of many nitro compounds, and of oxidation, as for instance the conversion of anthracene into anthraquinone. At the same time a number of other compounds, for example iodoform, are also prepared electrolytically.

Within recent years there have been great advances in the application of catalytic methods to industrial purposes. Some processes of this class have, of course, been in use for a considerable time, for example the Deacon chlorine process and the contact method for the manufacture of sulphuric acid, whilst the preparation of phthalic anhydride (largely used in the synthesis of indigo and other dyestuffs), by the oxidation of naphthalene with sulphuric acid with the assistance of mercuric sulphate as catalyst, is no novelty. More recent are the contact methods of obtaining ammonia by the direct combination of nitrogen and hydrogen, and of oxidizing ammonia to nitric acid—both of which are said to be in operation on a very large scale in Germany. The catalytic action of metals, particularly nickel and copper, is utilized in processes of hydrogenation—for example, the hardening of fats, and of dehydrogenation, as in the preparation of acetaldehyde from alcohol, and such metallic oxides as alumina and thoria can be used for processes of dehydration—*e. g.*, the preparation of ethylene or of ether from alcohol. Other catalysts employed in industrial processes are titanous chloride in electrolytic reductions and cerous sulphate in electrolytic oxidations of carbon compounds, gelatine in the preparation of hydrazine from ammonia, sodium in the synthesis of rubber, etc.

Other advances in manufacturing chemistry include the preparation of a number of the rarer elements and their compounds, which were hardly known thirty years ago, but which now find commercial applications. Included in this category are titanium, vanadium, tungsten and tantalum, now used in metallurgy or for electric-lamp filaments; thoria and ceria in the form of mantles for incandescent lamps; pyrophoric alloys of cerium and other metals; zirconia, which appears to be a most valuable refractory material; and compounds of radium and of mesothorium, for medical use as well as for research. Hydrogen, together with oxygen and nitrogen, are in demand for synthetic purposes, and the first also for lighter-than-air craft. Ozone is considerably used for sterilizing water and as an oxidizing agent, for example in the preparation of vanillin from isoeugenol and hydrogen peroxide, now obtainable

very pure in concentrated solution, and the peroxides of a number of the metals are also utilized in many different ways. The per- acids—perboric, percarbonic and persulphuric—or their salts are employed for oxidizing and bleaching purposes, and sodium hydrosulphite is much in demand as a reducing agent—*e. g.*, in dyeing with indigo. Hydroxylamine and hydrazine are used in considerable quantity, and the manufacture of cyanides by one or other of the modern methods has become quite an important industry, mainly owing to the use of the alkali salts in the cyanide process of gold extraction. These remarkable compounds, the metallic carbonyls, have been investigated, and nickel carbonyl is employed on the commercial scale in the extraction of the metal. Fine chemicals for analysis and research are now supplied, as a matter of course, in a state of purity rarely attained a quarter of a century ago.

In the organic chemical industry similar continued progress is to be noted. Accessions are constantly being made to the already enormous list of synthetic dyes, not only by the addition of new members to existing groups, but also by the discovery of entirely new classes of tinctorial compounds; natural indigo seems doomed to share the fate of alizarine from madder, and to be ousted by synthetic indigo, of which, moreover, a number of useful derivatives are also made. Synthetic drugs of all kinds—antipyrine and phenacetin, sulphonal and veronal, novacain and β-eucaine, salol and aspirin, piperazine and adrenaline, atoxyl and salvarsan—are produced in large quantities, as also are many synthetic perfumes and flavoring materials, such as ionone, heliotropine, and vanillin. Cellulose in the form of artificial silk is much used as a new textile material, synthetic camphor is on the market, synthetic rubber is said to be produced in considerable quantity; and the manufacture of materials for photographic work and of organic compounds for research purposes is no small part of the industry. However, it would serve no useful purpose to extend this catalogue, which might be done almost indefinitely.

British chemists are entitled to regard with satisfaction the part which they have taken in the development of scientific chemistry during the last three decades, as in the past, but with respect to the progress of industrial chemistry it must be regretfully admitted that, except in isolated cases, we have failed to keep pace with our competitors. Consider a single example. Although there still remain in South America considerable deposits of sodium nitrate which can be worked at a profit, it is clear that sooner or later other sources of nitric acid must be made available. The synthetic production of nitric acid from the air is now a commercial success; several different processes are in operation abroad, and Germany is reported to be quite independent of outside supplies. Electrical energy, upon the cost of which the success of the process largely depends, can be produced in this country at least as cheaply as in Germany, and yet we have done nothing in the matter, unless we count as something the appointment of a committee to consider possibilities. This case is only too typical of many others. A number of different causes have contributed to bring about this state of affairs, and the responsibility for it is assigned by some to the government, by others to the chemical manufacturers, and by still others to the professors of chemistry. I think, however, it will be generally admitted that the root of the matter is to be found in the general ignorance of and indifference to the methods and results of scientific work which characterize the people of this country. For many years past

our leaders in science have done all that lay in their power to awaken the country to the inevitable and deplorable results of this form of "sleeping sickness," but hitherto their reception has been much the same as that accorded to the hero of "The Pilgrim's Progress," as depicted in the following passage:

"He went on thus, even until he came at a bottom where he saw, a little out of the way, three Men fast asleep with Fetters upon their heels."

"The name of the one was *Simple,* another *Sloth,* and the third *Presumption.*"

"Christian, then seeing them in this case, went to them, if peradventure he might awaken them. And cried, You are like them that sleep on the top of a Mast, for the Dead Sea is under you, a Gulf that hath no bottom. Awake therefore and come away; be willing also, and I will help you off with your irons. He also told them, If he that goeth about like a *Roaring Lion* comes by, you well certainly become a prey to his teeth."

"With that they lookt upon him, and began to reply in this sort: *Simple* said, *I see no danger; Sloth* said, *Yet a little more sleep;* and *Presumption* said, *Every Vat must stand upon his own bottom.* And they lay down to sleep again, and *Christian* went on his way."

I believe that a brighter day is dawning, and that, if only we rise to the occasion *now,* chemistry in this country will attain the position of importance which is its due. Meantime it is of no avail to lament lost opportunities or to indulge in unprofitable recrimination; on the contrary, it should be our business to find a remedy for the "arrested development" of our chemical industry, and the task of establishing remedial measures should be taken in hand by the state, the universities and the chemical manufacturers themselves. As regards another very large group of interested persons, the consumers of chemical products, or in other words the nation as a whole, it is surely not too much to expect that they have been taught by the course of events since the outbreak of the war the folly of depending solely upon foreign and possibly hostile manufacturers, even although fiscal and other advantages may enable the alien to undersell the home producer. Considering that the future prosperity of the empire depends largely upon the well-being of its chemical industries, it is simply suicidal to permit these to be crippled or even crushed out of existence by competition on unequal terms.

The government has taken a most significant step in advance by appointing an advisory council for scientific and industrial research and providing it with funds; incidentally, in so doing, it has recognized the past failure of the state to afford adequate support to scientific work. The advisory council has lost no time in getting to work and has already taken steps to allocate grants in support of a number of investigations of first-rate importance to industry. In order to be in a position to do justice to the branches of industry concerned in proposed researches which have been submitted by institutions and individuals it has decided to appoint standing committees of experts and has already constituted strong committees in mining, metallurgy and in engineering; a committee in chemistry will no doubt be appointed in due course. The council also makes the gratifying intimation that the training of an adequate supply of research workers will be an important part of its work.

It is safe to prophesy that the money expended by the advisory council will sooner or later yield a goodly return, and this justifies the hope that the government will not rest satisfied with their achievement,

but will take further steps in the same direction. This desire for continued action finds strong support in the recommendations made by a sub-committee of the advisory committee to the board of trade on commercial intelligence, which was appointed to report with respect to measures for securing the position, after the war, of certain branches of British industry. Of these recommendations I quote the following:

"1. *Scientific Industrial Research and Training.*—(*a*) Larger funds should be placed at the disposal of the new committee of the privy council, and also of the board of education, for the promotion of scientific and industrial training. (*b*) The universities should be encouraged to maintain and extend research work devoted to the main industry or industries located in their respective districts, and manufacturers engaged in these industries should be encouraged to cooperate with the universities in such work, either through their existing trade associations or through associations specially formed for the purpose. Such associations should bring to the knowledge of the universities the difficulties and needs of the industries, and give financial and other assistance in addition to that afforded by the state. In the case of non-localized industries trade associations should be advised to seek, in respect of centers for research, the guidance of the advisory committee of the privy council. (*c*) An authoritative record of consultant scientists, chemists and engineers and of persons engaged in industrial research, should be established and maintained by some suitable government department for the use of manufacturers only."

"2. *Tariff Protection.*—Where the national supply of certain manufactured articles which are of vital importance to the national safety or are essential to other industries has fallen into the hands of manufacturers or traders outside this country, British manufacturers ready to undertake the manufacture of such articles in this country should be afforded sufficient tariff protection to enable them to maintain such production after the war." (It is also recommended by the sub-committee that in view of the threatened dumping of stocks which may be accumulated in enemy countries, the government should take such steps as would prevent the position of industries, likely to be affected, being endangered after the war.)

"3. *Patents.*—(*a*) The efforts which have been made to secure uniformity of patent law throughout the empire should be continued. (*b*) The provisions of the law as to the compulsory working of patents in the United Kingdom should be more rigorously enforced, and inspectors should be appointed to secure that such working is complete and not only partial."

The adoption by the government of these weighty recommendations would go far to establish British chemical industry on a secure basis, and would undoubtedly lead to the expansion of already existing branches and the establishment of new ones. Meanwhile, the Australian government has set an example which might be followed with great advantage. Shortly after the British scheme for the development of scientific and industrial research under the auspices of the advisory council had been made public, the prime minister of Australia determined to do still more for the commonwealth, with the object of making it independent of German trade and manufactures after the conclusion of the war. He therefore appointed a committee representative of the state scientific departments, the universities, and industrial interests, and within a very short period the committee produced a scheme for the estab-

lishment of a Commonwealth Institute of Science and Industry. The institute is to be governed by three directors, two of whom will be scientific men of high standing, while the third will be selected for proved ability in business. The directors are to be assisted by an advisory council composed of nine representatives of science and of industry; these representatives are to seek information, advice and assistance from specialists throughout Australia. The chief functions of the institute are (1) To ascertain what industrial problems are most pressing and most likely to yield to scientific experimental investigation, to seek out the most competent men to whom such research may be entrusted, and to provide them with all the necessary appliances and assistance. (2) To build up a bureau of scientific and industrial information, which shall be at the service of all concerned in the industries and manufactures of the commonwealth. (3) To erect, staff and control special research laboratories, the first of which will probably be a physical laboratory somewhat on the lines of our National Physical Laboratory. Other functions of the institute are the coordination and direction of research and experimental work with a view to the prevention of undesirable overlapping of effort, the recommendation of grants of the commonwealth government in aid of pure scientific research in existing institutions, and the establishment and award of industrial research fellowships.

This admirable scheme is more comprehensive and more generous than that of our government, but it could be rivaled without much difficulty. We already possess an important asset in the National Physical Laboratory, and there now exists the advisory council with its extensive powers and duties. What is lacking in our scheme, so far as chemistry is concerned, could be made good, firstly, by providing the advisory council with much larger funds. and, secondly, by the establishment of a National Chemical Laboratory—an institute for research in pure and applied chemistry—or by assisting the development of research departments in our universities and technical colleges (as is now being done in America), or, better still, by moving in both directions. With respect to the second alternative, I do not mean to suggest that research work is neglected in the chemistry departments of any of our higher institutions; what I plead for is the provision of greater facilities for the prosecution of investigation not only in pure but also in applied chemistry. As things are at present, the professors and lecturers are for the most part so much occupied in teaching and in administration as to be unable to devote time uninterruptedly to research work, which demands above all things continuity of effort. The ideal remedy would be the institution of research professorships, but, failing this, the burden of teaching and administrative work should be lightened by appointing larger staffs.

It has been suggested by Dr. Forster that the state could render assistance to chemical industry in another way, namely, by the formation of a Chemical Intelligence Department of the Board of Trade, which should be concerned with technical, commercial and educational questions bearing upon the industry. Under the first head the proposed department would have the duty (*a*) of collecting, tabulating and distributing all possible information regarding chemical discoveries, patents, and manufacturing processes, and (*b*) of presenting problems for investigation to research chemists, of course under proper safeguards and with suitable remuneration. The more strictly commercial side of the department's activities would be concerned with the

classification of the resources of the empire as regards raw materials, and of foreign chemical products in respect of distribution throughout the world, with ruling prices, tariffs, cost of transport, and if possible cost of production. On the educational side it is suggested that the department should collect data regarding opportunities for chemical instruction and research in various parts of the empire, and should consider possible improvements and extensions of these. The department would of course be in charge of a highly trained chemist, with a sufficient number of chemical assistants.

This proposal, which has been widely discussed and on the whole very favorably received by chemists, has much to recommend it; to mention only one point, the unrivalled resources of the Board of Trade would facilitate the acquisition of information which might otherwise be difficult to obtain, or which would not be disclosed except to a government department. The principal objections which have been raised are based upon the fear that the proposed department, however energetic and enterprising it might be at the start, would soon be so helplessly gagged and bound down by departmental red tape as to become of little or no service. This danger, however, could be obviated to a great extent by the institution of a strong advisory committee, representative of and elected by the societies concerned with the different branches of chemistry, which would keep closely in touch with the Chemical Intelligence Department on the one hand and with the industry on the other, and which would act as adviser of the permanent scientific staff of the department. There is, I fear, little chance of seeing Dr. Forster's proposal carried into effect unless all the societies concerned move actively and unitedly in the matter; they must do the pioneer work and must submit a definite scheme to the government, if the desired result is to be attained. In the not improbable contingency that the board of trade will decline to take action, I trust that the scheme for the establishment of an Information Bureau—on lines similar to but somewhat less wide-reaching than those which I have just indicated—which has been under the careful consideration of the Council of the Society of Chemical Industry, will be vigorously prosecuted. Difficulties, chiefly financial, stand in the way, but these are not insuperable, especially if the sympathy and support of the government can be enlisted.

Unless the conditions and methods which have ruled in the past are greatly altered it is hardly possible to hope that the future prospects of our chemical industry will be bright; it is essential that the representatives of the industry should organize themselves in their own interest and cooperate in fighting the common enemy. More than ever is this the case when, as we are informed, three different groups of German producers of dyes, drugs and fine chemicals, who own seven large factories, have formed a combination with a capital of more than £11,000,000, and with other assets of very great value in the shape of scientific, technical and financial efficiency. Hence it is eminently satisfactory to be able to record the active progress of a movement, originated by the Chemical Society, which has culminated in the formation of an Association of British Chemical Manufacturers. The main objects of the association are to promote cooperation between British chemical manufacturers; to act as a medium for placing before the government and government officials the views of manufacturers upon matters affecting the chemical industry; to develop technical organization and promote industrial research; to keep in

touch with the progress of chemical knowledge and to facilitate the development of new British industries and the extension of existing ones; and to encourage the sympathetic association of British manufacturers with the various universities and technical colleges.

Needless to say, the progress of this important movement will be assisted by everyone who is interested, either directly or indirectly, in the welfare of our chemical industry, and, moreover, the support of the scientific societies will not be lacking, for, as the result of a conference convened by the President and Council of the Royal Society, a Conjoint Board of Scientific Societies has been constituted, for the furtherance of the following objects: Promoting the cooperation of those interested in pure or applied science; supplying a means whereby scientific opinion may find effective expression on matters relating to science, industry and education; taking such action as may be necessary to promote the application of science to our industries and to the service of the nation; and discussing scientific questions in which international cooperation seems advisable.

In an address given to the Society of Chemical Industry last year, I indicated another way in which chemical manufacturers can help themselves and at the same time promote the interests of chemistry in this country. In the United States of America individual manufacturers, or associations of manufacturers, have shown themselves ready to take up the scheme originated by the late Professor Duncan for the institution of industrial research scholarships tenable at the universities or technical colleges, and the results obtained after ten years' experience of the working of this practical method of promoting cooperation between science and industry have more than justified the anticipations of its originator. The scheme is worthy of adoption on many grounds, of which the chief are that it provides definite subjects for technical research to young chemists qualified for such work, that it usually leads to positions in factories for chemists who have proved their capacity through the work done while holding scholarships, and that it reacts for good on the profession generally, by bringing about that more intimate intercourse between teachers and manufacturers which is so much to be desired.

In this connection the recent foundation of the Willard Gibbs chair of research in pure chemistry at the University of Pittsburgh is extremely significant, for it shows that even in such a purely industrial community as Pittsburgh it is recognized that the most pressing need of the day is the endowment of chemical research and the creation of research professorships. Mr. A. P. Fleming, who recently made a tour of inspection of research laboratories in the United States, points to the amount of work done by individual firms and the increased provision now being made for research in universities and technical institutions. He reports that at the present time there are upwards of fifty corporations having research laboratories, costing annually from £20,000 to £100,000 for maintenance, and states that "some of the most striking features of the research work in America are the lavish manner in which the laboratories have been planned, which in many cases enables large scale operations to be carried out in order to determine the best possible methods of manufacturing any commodity developed or discovered in the laboratories; the increasing attention given in the research laboratories to pure science investigation, this being, in my opinion, the most important phase of industrial research; and the absorption of

men who have proved their capacity for industrial research in such places as the Mellon Institute, the Bureau of Standards, etc., by the various industries in which they have taken scientific interest." It is evidently the view of American manufacturers that industrial research can be made to pay for itself, and that to equip and maintain research laboratories is an excellent investment.

It can not be too often reiterated that no branch of chemical industry can afford to stand still, for there is no finality in manufacturing processes; all are capable of improvement, and for this, as well as for the discovery and the application of new processes, the services of the trained chemist are essential. Hence the training of chemists for industrial work is a matter of supreme importance. We may therefore congratulate ourselves that the opportunities for chemical instruction in this country are immensely greater than they were thirty years ago. The claims of chemistry to a leading position have been recognized by all our universities, even the most ancient, by the provision of teaching staffs, laboratories, and equipment on a fairly adequate if not a lavish scale, and in this respect many of the technical colleges fall not far behind. The evening classes conducted in a large number of technical institutions are hardly fitted to produce fully trained chemists, if only because lack of the necessary time prevents the student from obtaining that prolonged practise in the laboratory which cannot be dispensed with, unless indeed he is prepared to go through a course of study extending over many years. At the same time these evening classes play a most important part, firstly in disseminating a knowledge of chemistry throughout the country, and secondly in affording instruction of a high order in special branches of applied chemistry. Finally, in a large and increasing number of schools a more or less satisfactory introduction to the science is given by well-qualified teachers. With our national habit of self-depreciation we are apt to overlook the steady progress which has been made, but at the same time I do not suggest that there is no room for improvement of our system of training chemists. Progress in every department of industrial chemistry is ultimately dependent upon research, and therefore a sufficient supply of chemists with practical knowledge and experience of the methods of research is vital. This being so, it is an unfortunate thing that so many students are allowed to leave the universities in possession of a science degree but without any experience in investigation. The training of the chemist, so far as that training can be given in a teaching institution, must be regarded as incomplete unless it includes some research work, not, of course, because every student has the mental gifts which characterize the born investigator, but rather because of the inestimable value of the experience gained when he has to leave the beaten track and to place more dependence upon his own initiative and resource. Consequently one rejoices to learn that at the University of Oxford no candidate can now obtain an honors degree without having produced evidence that he has taken part in original research, and that the General Board of Studies at Cambridge has also made proposals which, if adopted, will have the effect of encouraging systematic research work. Perhaps it is too much to expect that practise in research will be made an indispensable qualification for the ordinary degree; failing this, and indeed in every case, promising students should be encouraged, by the award of research scholarships, to continue their studies for a period of at least two years after taking

the B.Sc. degree, and to devote that time to research work which would qualify for a higher degree. In this connection an excellent object-lesson is at hand, for the output of research work from the Scottish universities has very greatly increased since the scheme of the Carnegie Trust for the institution of research scholarships has come into operation. Thanks to these scholarships, numbers of capable young graduates, who otherwise for the most part would have had to seek paid employment as soon as their degree courses were completed, have been enabled to devote two or more years to research work. Of course it must be recognized that not every chemist has the capacity to initiate or inspire investigation, and that no amount of training, however thorough and comprehensive, will make a man an investigator unless he has the natural gift. At the same time, whilst only the few are able to originate really valuable research work, a large army of disciplined men who have had training in the methods of research is required to carry out experimentally the ideas of the master mind. Moreover, there is ample scope in industrial work for chemists who, although not gifted with initiative as investigators, are suitably equipped to supervise and control the running of large-scale processes, the designing of appropriate plant, the working out on the manufacturing scale of new processes or the improvement of existing ones—men of a thoroughly practical mind, who never lose sight of costs, output and efficiency, and who have a sufficient knowledge of engineering to make their ideas and suggestions clear to the engineering expert. Further, there has to be considered the necessity for the work of the skilled analyst in the examination of raw materials and the testing of intermediate and finished products, although much of the routine work of the industrial laboratory will advisedly be left in the hands of apprentices working under the control of the chemist. Lastly, for the buying and selling of materials there should be a demand for the chemist with the commercial faculty highly developed. There is, indeed, in any large industrial establishment room for chemists of several different types, but all of these should have had the best possible training, and it must be the business of our higher teaching institutions to see that this training is provided.

On more than one occasion I have expressed the opinion that every chemist who looks forward to an industrial post should receive in the course of his training a certain amount of instruction in chemical engineering, by means of lectures and also of practical work in laboratories fitted out for the purpose. The practicability of this has been proved in more than one teaching institution, and experience has convinced me that chemists who have had such a course are generally more valuable in a works—whether their ultimate destination is the industrial research laboratory or the control of manufacturing operations—than those who have not had their studies directed beyond the traditional boundaries of pure chemistry. (I used the word "traditional" because to my mind there is no boundary line between the domains of pure and of applied chemistry.) A course in chemical engineering, preferably preceded by a short course in general engineering and drawing, must, however, be introduced as *a supplement to,* and not as *a substitute for,* any part of the necessary work in pure chemistry, and consequently the period of undergraduate study will be lengthened if such a course is included; this is no disadvantage, but quite the contrary. I am glad to say that the University of Glasgow has recently instituted a degree in applied chemistry, for which the curriculum in-

cludes chemical engineering in addition to the usual courses in chemistry, and I hope that a place will be found for this subject by other universities.

On the whole, there is not much fault to be found with the training for chemists supplied by the universities and technical colleges, but there is still room for improvements which could and would be carried out if it were not that the scientific departments of these institutions are as a rule hampered by lack of funds. The facilities for practical instruction with respect to accommodation and equipment are generally adequate, but, on the other hand, the *personnel* could with advantage be largely increased, and at least the junior members of the staffs are miserably underpaid. It would doubtless be regarded as insanity to suggest that a scientific man, however eminent, should receive more than a fraction of the salary to which a music-hall "artiste" or a lawyer politician can aspire; but if the best brains in the country are to be attracted towards science, as they ought to be, some greater inducement than a mere living wage should be held out. Hence no opportunity should be lost of impressing upon the government the necessity for increasing the grants to the scientific departments of our higher teaching institutions, and for the provision of research scholarships. It is much to be desired also that wealthy men in this country should take an example from America and acquire more generally the habit of devoting some part of their means to the endowment of higher education. The private donations for science and education made in the United States during the last forty-three years amount to the magnificent sum of £117,000,000, and recently the average annual benefactions for educational purposes total nearly £6,000,000. Of course there are few, if any, of the universities and colleges in this country which are not deeply indebted to the foresight and generosity of private benefactors, but the lavish scale on which funds are provided in America leads to a certain feeling of admiring envy.

After all, the chief difficulty which confronts those who are eager for progress in educational matters is that so many of our most famous schools are still conducted on medieval lines, in the sense that the "education" administered is almost wholly classical. Consequently, "though science enters into every part of modern life, and scientific method is necessary for success in all undertakings, the affairs of the country are in the hands of legislators who not only have little or no acquaintance with the fundamental facts and principles signified by these aspects of knowledge, but also do not understand how such matters can be used to strengthen and develop the state. Our administrative officials are also mostly under the same disabilities, on account of their want of a scientific training. They are educated at schools where science can receive little encouragement, and they do not take up scientific subjects in the examinations for the civil service, because marks can be much more easily obtained by attention to Latin and Greek; and the result of it all is that science is usually treated with indifference, often with contempt, and rarely with intelligent appreciation by the statesmen and members of the public services whose decisions and acts largely determine the country's welfare. The defects of a system which places the chief power of an organization which needs understanding of science in every department in the hands of people who have not received any training in scientific subjects or methods are obvious."[2] The remedy is also obvious.

Here, again, the prospects are now

[2] *Nature*, February 10, 1916.

brighter than ever before, because the warnings and appeals of men of science have at last, and after many years, begun to bear fruit, or perhaps it would be more correct to say the lessons of the war have begun to make an impression on the powers that be. Within the last few weeks it has been intimated that the government, giving ear to what has been uttered, incessantly and almost *ad nauseam,* with regard to British neglect of science, proposes to appoint a committee to inquire into the position of science in our national system of education, especially in universities and secondary schools. The duty of the committee will be to advise the authorities how to promote the advancement of pure science, and also the interests of trade, industries and professions dependent on the application of science, bearing in mind the needs of what is described as a liberal education. It is stated that the committee will include scientific men in whom the country will have confidence, some of those who appreciate the application of science to commerce and industry, and some who are able from general experience to correlate scientific teaching with education as a whole. I am sure that we may look forward with confidence to the recommendations of such a committee, and we shall hope, for the sake of our country, that their recommendations will be adopted and put in force with the least possible delay.

G. G. Henderson

NEW ARCHEOLOGICAL LIGHTS ON THE ORIGIN OF CIVILIZATION IN EUROPE. II

It is a commonplace of archeology that the culture of the Neolithic peoples throughout a large part of central, northern and western Europe—like the newly domesticated species possessed by them—is Eurasiatic in type. So, too, in southern Greece and the Ægean world we meet with a form of Neolithic culture which must be essentially regarded as a prolongation of that of Asia Minor.

It is clear that it is on this Neolithic foundation that our later civilization immediately stands. But in the constant chain of actions and reactions by which the history of mankind is bound together—short of the extinction of all concerned, a hypothesis in this case excluded—it is equally certain that no great human achievement is without its continuous effect. The more we realize the substantial amount of progress of the men of the Late Quaternary Age in arts and crafts and ideas, the more difficult it is to avoid the conclusion that somewhere "at the back of behind"—it may be by more than one route and on more than one continent, in Asia as well as Africa—actual links of connection may eventually come to light.

Of the origins of our complex European culture this much at least can be confidently stated: the earliest extraneous sources on which it drew lay respectively in two directions—in the valley of the Nile, on one side, and in that of the Euphrates, on the other.

Of the high early culture in the lower Euphrates valley our first real knowledge has been due to the excavations of De Sarzec in the mounds of Tello, the ancient Lagash. It is now seen that the civilization that we call Babylonian, and which was hitherto known under its Semitic guise, was really in its main features an inheritance from the earlier Sumerian race—culture in this case once more dominating nationality. Even the laws which Hammurabi traditionally received from the Babylonian Sun God were largely modelled on the reforms enacted a thousand years earlier by his predecessor, Urukagina, and ascribed by him to the inspira-

tion of the City God of Lagash.[10] It is hardly necessary to insist on the later indebtedness of our civilization to this culture in its Semitized shape, as passed on, together with other more purely Semitic elements, to the Mediterranean world through Syria, Canaan and Phœnicia, or by way of Assyria, and by means of the increasing hold gained on the old Hittite region of Anatolia.

Even beyond the ancient Mesopotamian region which was the focus of these influences, the researches of De Morgan, Gautier and Lampre, of the French "Délégation en Perse," have opened up another independent field, revealing a nascent civilization equally ancient, of which Elam—the later Susiana—was the center. Still further afield, moreover—some three hundred miles east of the Caspian—the interesting investigations of the Pumpelly Expedition in the mounds of Anau, near Ashkabad in southern Turkestan, have brought to light a parallel and related culture. The painted Neolithic sherds of Anau, with their geometrical decoration, similar to contemporary ware of Elam, have suggested wide comparisons with the painted pottery of somewhat later date found in Cappadocia and other parts of Anatolia, as well as in the North Syrian regions. It has, moreover, been reasonably asked whether another class of painted Neolithic fabrics, the traces of which extend across the steppes of southern Russia, and, by way of that ancient zone of migration, to the lower Danube and northern Greece, may not stand in some original relation to the same ancient province. The new discoveries, however, in the mounds of Elam and Anau have at most a bearing on the primitive phase of culture in parts of southeastern Europe that preceded the age when metal was generally in use.

[10] See L. W. King, "History of Sumer and Akkad," p. 184.

Turning to the Nile Valley we are again confronted with an extraordinary revolution in the whole point of view effected during recent years. Thanks mainly to the methodical researches initiated by Flinders Petrie, we are able to look back beyond the Dynasties to the very beginnings of Egyptian civilization. Already by the closing phase of the Neolithic and by the days of the first incipient use of metals the indigenous population had attained an extraordinarily high level. If, on the one hand, it displays Libyan connections, on the other, we already note the evidences of commercial intercourse with the Red Sea; and the constant appearance of large rowing vessels in the figured designs shows that the Nile itself was extensively used for navigation. Flint-working was carried to unrivalled perfection, and special artistic refinement was displayed in the manufacture of vessels of variegated breccia and other stones. The antecedent stages of many Egyptian hieroglyphs are already traceable, and the cult of Egyptian divinities, like Min, was already practised. Whatever ethnic change may have marked the establishment of Pharaonic rule, here, too, the salient features of the old indigenous culture were taken over by the new régime. This early dynastic period itself has also received entirely new illustration from the same researches, and the freshness and force of its artistic works in many respects outshine anything produced in the later course of Egyptian history.

The continuity of human tradition, as a whole, in areas geographically connected like Eurafrica, on the one side, and Eurasia, on the other, has been here postulated. Since, as we have seen, the Late Palæolithic culture was not violently extinguished but shows signs of survival, both north and south, we are entitled to trace elements of direct derivation from this source among the inherited acquire-

ments that finally led up to the higher forms of ancient civilization that arose on the Nile and the Euphrates. In many directions, we may believe, the flaming torch had been carried on by the relay runners.

But what, it may be asked, of Greece itself, where human culture reached its highest pinnacle in the ancient world and to which we look as the principal source of our own civilization?

Till within recent years it seemed almost a point of honor for classical scholars to regard Hellenic civilization as a Wonder-Child, sprung, like Athena herself, fully panoplied from the head of Zeus. The indebtedness to Oriental sources was either regarded as comparatively late or confined to such definite borrowings as the alphabet or certain weights and measures. Egypt, on the other hand, at least till Alexandrine times, was looked on as something apart, and it must be said that Egyptologists, on their side, were only too anxious to preserve their sanctum from profane contact.

A truer perspective has now been opened out. It has been made abundantly clear that the rise of Hellenic civilization was itself part of a wider economy and can be no longer regarded as an isolated phenomenon. Indirectly, its relation to the greater world and to the ancient centers to the south and east has been now established by its affiliation to the civilization of prehistoric Crete and by the revelation of the extraordinarily high degree of proficiency that was there attained in almost all departments of human art and industry. That Crete itself—the "Mid-Sea land," a kind of halfway house between three continents—should have been the cradle of our European civilization was, in fact, a logical consequence of its geographical position. An outlier of mainland Greece, almost opposite the mouths of the Nile, primitive intercourse between Crete and the further shores of the Libyan Sea was still further facilitated by favorable winds and currents. In the eastern direction, on the other hand, island stepping-stones brought it into easy communication with the coast of Asia Minor, with which it was actually connected in late geological times.

But the extraneous influences that were here operative from a remote period encountered on the island itself a primitive indigenous culture that had grown up there from immemorial time. In view of some recent geological calculations, such as those of Baron De Geer, who by counting the number of layers of mud in Lake Ragunda has reduced the ice-free period in Sweden to 7,000 years, it will not be superfluous to emphasize the extreme antiquity that seems to be indicated for even the later Neolithic in Crete. The Hill of Knossos, upon which the remains of the brilliant Minoan civilization have found their most striking revelation, itself resembles in a large part of its composition a great mound or tell—like those of Mesopotamia or Egypt—formed of layer after layer of human deposits. But the remains of the whole of the later ages represented down to the earliest Minoan period (which itself goes back to a time contemporary with the early Dynasties of Egypt—at a moderate estimate to B.C. 3400) occupy considerably less than a half—19 feet, that is, out of a total of over 45. Such calculations can have only a relative value, but, even if we assume a more rapid accumulation of débris for the Neolithic strata and deduct a third from our calculation, they would still occupy a space of over 3,400 years, giving a total antiquity of some 9,000 years from the present time.[11] No Neolithic section in Europe can compare in extent with that of Knossos, which itself can be divided by the character of its con-

[11] For a fuller statement I must refer to my forthcoming work, "The Nine Minoan Periods" (Macmillans), Vol. I.: Neolithic Section.

tents into an Early, Middle and Late phase. But its earliest stratum already shows the culture in an advanced stage, with carefully ground and polished axes and finely burnished pottery. The beginnings of Cretan Neolithic must go back to a still more remote antiquity.

The continuous history of the Neolithic Age is carried back at Knossos to an earlier epoch than is represented in the deposits of its geographically related areas on the Greek and Anatolian side. But sufficient materials for comparison exist to show that the Cretan branch belongs to a vast province of primitive culture that extended from southern Greece and the Ægean islands throughout a wide region of Asia Minor and probably still further afield.

An interesting characteristic is the appearance in the Knossian deposits of clay images of squatting female figures of a pronouncedly steatopygous conformation and with hands on the breasts. These in turn fit on to a large family of similar images which recur throughout the above era, though elsewhere they are generally known in their somewhat developed stage, showing a tendency to be translated into stone, and finally—perhaps under extraneous influences both from the north and east—taking a more extended attitude. These clearly stand in a parallel relationship to a whole family of figures with the organs of maternity strongly developed that characterize the Semitic lands and which seem to have spread from there to Sumeria and to the seats of the Anau culture.

At the same time this steatopygous family, which in other parts of the Mediterranean basin ranges from prehistoric Egypt and Malta to the north of mainland Greece, calls up suggestive reminiscences of the similar images of Aurignacian Man. It is especially interesting to note that in Crete, as in the Anatolian region where these primitive images occur, the worship of a Mother Goddess predominated in later times, generally associated with a divine child—a worship which later survived in a classical guise and influenced all later religion. Another interesting evidence of the underlying religious community between Crete and Asia Minor is the diffusion in both areas of the cult of the Double Axe. This divine symbol, indeed, or "Labrys," became the special emblem of the Palace sanctuary of Knossos itself, which owes to it its traditional name of Labyrinth. I have already called attention to the fact that the absorptive and disseminating power of the Roman Empire brought the cult of a male form of the divinity of the Double Axe to the Roman Wall and to the actual site on which Newcastle stands.

The fact should never be left out of sight that the gifted indigenous stock which in Crete eventually took to itself, on one hand and the other, so many elements of exotic culture, was still deep-rooted in its own. It had, moreover, the advantages of an insular people in taking what it wanted and no more. Thus it was stimulated by foreign influences but never dominated by them, and there is nothing here of the servility of Phœnician art. Much as it assimilated, it never lost its independent tradition.

It is interesting to note that the first quickening impulse came to Crete from the Egyptian and not from the Oriental side—the eastern factor, indeed, is of comparatively late appearance. My own researches have led me to the definite conclusion that cultural influences were already reaching Crete from beyond the Libyan Sea before the beginning of the Egyptian dynasties. These primitive influences are attested, amongst other evidences, by the forms of stone vessels, by the same esthetic tradition in the selection of materials distinguished by their polychromy, by the ap-

pearance of certain symbolic signs, and the subjects of shapes and seals which go back to prototypes in use among the "Old Race" of the Nile Valley. The impression of a very active agency indeed is so strong that the possibility of some actual immigration into the island of the older Egyptian element, due to the conquests of the first Pharaohs, can not be excluded.

The continuous influence of Dynastic Egypt from its earliest period onwards is attested both by objects of import and their indigenous imitations, and an actual monument of a middle empire Egyptian was found in the Palace Court at Knossos. More surprising still are the cumulative proofs of the reaction of this early Cretan civilization on Egypt itself, as seen not only in the introduction there of such beautiful Minoan fabrics as the elegant polychrome vases, but in the actual impress observable on Egyptian art even on its religious side. The Egyptian griffin is fitted with Minoan wings. So, too, on the other side we see the symbols of Egyptian religion impressed into the service of the Cretan Nature Goddess, who in certain respects was partly assimilated with Hathor, the Egyptian Cow-Goddess of the Underworld.

My own most recent investigations have more and more brought home to me the all-pervading community between Minoan Crete and the land of the Pharaohs. When we realize the great indebtedness of the succeeding classical culture of Greece to its Minoan predecessor the full significance of this conclusion will be understood. Ancient Egypt itself can no longer be regarded as something apart from general human history. Its influences are seen to lie about the very cradle of our own civilization.

The high early culture, the equal rival of that of Egypt and Babylonia, which thus began to take its rise in Crete in the fourth millennium before our era, flourished for some two thousand years, eventually dominating the Ægean and a large part of the Mediterranean basin. To the civilization, as a whole, I ventured, from the name of the legendary king and law-giver of Crete, to apply the name of "Minoan," which has received general acceptance; and it has been possible now to divide its course into three ages—Early, Middle and Late, answering roughly to the successive Egyptian kingdoms, and each in turn with a triple subdivision.

It is difficult indeed in a few words to do adequate justice to this earliest of European civilizations. Its achievements are too manifold. The many-storeyed palaces of the Minoan priest-kings in their great days, by their ingenious planning, their successful combination of the useful with the beautiful and stately, and, last but not least, by their scientific sanitary arrangements, far outdid the similar works, on however vast a scale, of Egyptian or Babylonian builders. What is more, the same skilful and commodious construction recurs in a whole series of private mansions and smaller dwellings throughout the island. Outside "broad Knossos" itself, flourishing towns sprang up far and wide on the country sides. New and refined crafts were developed, some of them, like that of the inlaid metal-work, unsurpassed in any age or country. Artistic skill, of course, reached its acme in the great palaces themselves, the corridors, landings and porticoes of which were decked with wall paintings and high reliefs, showing in the treatment of animal life not only an extraordinary grasp of nature, but a grandiose power of composition such as the world had never seen before. Such were the great bull-grappling reliefs of the Sea Gate at Knossos and the agonistic scenes of the great palace hall.

The modernness of much of the life here revealed to us is astonishing. The elabora-

tion of the domestic arrangements, the staircases story above story, the front places given to the ladies at shows, their fashionable flounced robes and jackets, the gloves sometimes seen on their hands or hanging from their folding chairs, their very mannerisms as seen on the frescoes, pointing their conversation with animated gestures—how strangely out of place would it all appear in a classical design! Nowhere, not even at Pompeii, have more living pictures of ancient life been called up for us than in the Minoan Palace of Knossos. The touches supplied by its closing scene are singularly dramatic—the little bath-room opening out of the Queen's parlor, with its painted clay bath, the royal draught-board flung down in the court, the vessels for anointing and the oil-jar for their filling ready to hand by the throne of the Priest-King, with the benches of his Consistory round and the sacred griffins on either side. Religion, indeed, entered in at every turn. The palaces were also temples, the tomb a shrine of the Great Mother. It was perhaps owing to the religious control of art that among all the Minoan representations—now to be numbered by thousands—no single example of indecency has come to light.

A remarkable feature of this Minoan civilization can not be passed over. I remember that at the Liverpool meeting of this association in 1896—just before the first results of the new discoveries in Crete were known—a distinguished archeologist took as the subject of an evening lecture "Man before Writing," and, as a striking example of a high culture attained by "*Analfabeti,*" singled out that of Mycenæ—a late offshoot, as we know now, from Minoan Crete. To such a conclusion, based on negative evidence, I confess I could never subscribe—for had not even the people of the Reindeer Age attained to a considerable proficiency in expression by means of symbolic signs? To-day we are able to trace the gradual evolution on Cretan soil of a complete system of writing from its earliest pictographic shape, through a conventionalized hieroglyphic to a linear stage of great perfection. In addition to inscribed sealings and other records some two thousand clay tablets have now come to light, mostly inventories or contracts; for though the script itself is still undeciphered the pictorial figures that often appear on these documents supply a valuable clue to their contents. The numeration also is clear, with figures representing sums up to 10,000. The inscribed sealings, signed, counter-marked and counter-signed by controlling officials, give a high idea of the elaborate machinery of government and administration under the Minoan rulers.

The minutely organized legal conditions to which this points confirm the later traditions of Minos, the great law-giver of prehistoric Crete, who, like Hammurabi and Moses, was said to have received the law from the God of the Sacred Mountain. The clay tablets themselves were certainly due to Oriental influences, which make themselves perceptible in Crete at the beginning of the Late Minoan Age, and may have been partly resultant from the reflex action of Minoan colonization in Cyprus. From this time onwards eastern elements are more and more traceable in Cretan culture, and are evidenced by such phenomena as the introduction of chariots—themselves perhaps more remotely of Aryan-Iranian derivation—and by the occasional use of cylinder seals.

Simultaneously with its eastern expansion, which affected the coast of Phœnicia and Palestine as well as Cyprus, Minoan civilization now took firm hold of mainland Greece, while traces of its direct influence are found in the west Mediterranean basin —in Sicily, the Balearic Islands and Spain.

At the time of the actual conquest and during the immediately succeeding period the civilization that appears at Mycenæ and Tiryns, at Thebes and Orchomenos, and at other centers of mainland Greece, though it seems to have brought with it some already assimilated Anatolian elements, is still in the broadest sense Minoan. It is only at a later stage that a more provincial offshoot came into being to which the name Mycenæan can be properly applied. But it is clear that some vanguard at least of the Aryan Greek immigrants came into contact with this high Minoan culture at a time when it was still in its most flourishing condition. The evidence of Homer itself is conclusive. Arms and armor described in the poems are those of the Minoan prime, the fabled shield of Achilles, like that of Herakles described by Hesiod, with its elaborate scenes and variegated metal-work, reflects the masterpieces of Minoan craftsmen in the full vigor of their art; the very episodes of epic combat receive their best illustration on the signets of the great days of Mycenæ. Even the lyre to which the minstrel sang was a Minoan invention. Or, if we turn to the side of religion, the Greek temple seems to have sprung from a Minoan hall, its earliest pediment schemes are adaptations from the Minoan tympanum—such as we see in the Lions' Gate—the most archiac figures of the Hellenic Goddesses, like the Spartan Orthia, have the attributes and attendant animals of the great Minoan Mother.

Some elements of the old culture were taken over on the soil of Hellas. Others which had been crushed out in their old centers survived in the more eastern shores and islands formerly dominated by Minoan civilization, and were carried back by Phœnician or Ionian intermediaries to their old homes. In spite of the overthrow which about the twelfth century before our era fell on the old Minoan dominion and the onrush of the new conquerors from the north, much of the old tradition still survived to form the base for the fabric of the later civilization of Greece. Once more, through the darkness, the lighted torch was carried on, the first glimmering flame of which had been painfully kindled by the old Cave dwellers in that earlier Palæolithic world.

The Roman Empire, which in turn appropriated the heritage that Greece had received from Minoan Crete, placed civilization on a broader basis by welding together heterogeneous ingredients and promoting a cosmopolitan ideal. If even the primeval culture of the Reindeer Age embraced more than one race and absorbed extraneous elements from many sides, how much more is that the case with our own which grew out of the Greco-Roman! Civilization in its higher form to-day, though highly complex, forms essentially a unitary mass. It has no longer to be sought out in separate luminous centers, shining like planets through the surrounding night. Still less is it the property of one privileged country or people. Many as are the tongues of mortal men, its votaries, like the Immortals, speak a single language. Throughout the whole vast area illumined by its quickening rays, its workers are interdependent, and pledged to a common cause.

We, indeed, who are met here to-day to promote in a special way the Cause of Truth and Knowledge, have never had a more austere duty set before us. I know that our ranks are thinned. How many of those who would otherwise be engaged in progressive research have been called away for their country's service! How many who could least be spared were called to return no more! Scientific intercourse is broken, and its cosmopolitan character is obscured by the death struggle in which whole continents are locked. The concentration, moreover, of the nation and of its

government on immediate ends has distracted it from the urgent reforms called for by the very evils that are the root cause of many of the greatest difficulties it has had to overcome. It is a lamentable fact that beyond any nation of the west the bulk of our people remains sunk not in comparative ignorance only—for that is less difficult to overcome—but in intellectual apathy. The dull incuria of the parents is reflected in the children, and the desire for the acquirement of knowledge in our schools and colleges is appreciably less than elsewhere. So, too, with the scientific side of education, it is not so much the actual amount of science taught that is in question—insufficient as that is—as the instillation of the scientific spirit itself—the perception of method, the sacred thirst for investigation.

But can we yet despair of the educational future of a people that has risen to the full height of the great emergency with which they were confronted? Can we doubt that, out of the crucible of fiery trial, a New England is already in the moulding?

We must all bow before the hard necessity of the moment. Of much we can not judge. Great patience is demanded. But let us, who still have the opportunity of doing so, at least prepare for the even more serious struggle that must ensue against the enemy in our midst, that gnaws our vitals. We have to deal with ignorance, apathy, the non-scientific mental attitude, the absorption of popular interest in sports and amusements.

And what, meanwhile, is the attitude of those in power—of our government, still more of our permanent officials? A cheap epigram is worn threadbare in order to justify the ingrained distrust of expert, in other words of scientific, advice on the part of our public offices. We hear, indeed, of "Commissions" and "Enquiries," but the inveterate attitude of our rulers towards the higher interests that we are here to promote is too clearly shown by a single episode. It is those higher interests that are the first to be thrown to the wolves. All are agreed that special treasures should be stored in positions of safety, but at a time when it might have been thought desirable to keep open every avenue of popular instruction and of intelligent diversion, the galleries of our National Museum at Bloomsbury were entirely closed for the sake of the paltriest saving—three minutes, it was calculated, of the cost of the war to the British treasury! That some, indeed, were left open elsewhere was not so much due to the enlightened sympathy of our politicians, as to their alarmed interests in view of the volume of intelligent protest. Our friends and neighbors across the Channel, under incomparably greater stress, have acted in a very different spirit.

It will be a hard struggle for the friends of science and education and the air is thick with mephitic vapors. Perhaps the worst economy to which we are to-day reduced by our former lack of preparedness is the economy of truth. Heaven knows!—it may be a necessary penalty. But its results are evil. Vital facts that concern our national well-being, others that even affect the cause of a lasting peace, are constantly suppressed by official action. The negative character of the process at work which conceals its operation from the masses makes it the more insidious. We live in a murky atmosphere amidst the suggestion of the false, and there seems to be a real danger that the recognition of truth as itself a tower of strength may suffer an eclipse.

It is at such a time and under these adverse conditions that we, whose object it is to promote the advancement of science, are called upon to act. It is for us to see to it that the lighted torch handed down to us

from the ages shall be passed on with a still brighter flame. Let us champion the cause of education, in the best sense of the word, as having regard to its spiritual as well as its scientific side. Let us go forward with our own tasks, unflinchingly seeking for the truth, confident that, in the eternal dispensation, each successive generation of seekers may approach nearer to the goal.

Magna est veritas, et prævalebit.

Arthur Evans
University of Oxford

THE IMPORTANCE OF SCIENTIFIC RESEARCH TO THE INDUSTRIES

America is in the throes of preparedness and many are the remedies offered for quick deliverance. These remedies are of two varieties, namely, genuine and quack; and at times it may be difficult to dissociate one from the other.

Schemes of all kinds are offered purporting to be of immediate and direct value in the program of national defense, but when sifted to the bottom are found to be, either wholly valueless, or detrimental to the cause. On the other hand, the national awakening to the necessity of providing adequate defense has been productive of measures and plans which, if carried through, would result in permanent assets to the country.

The conclusion seems to be warranted, that the major efforts in our preparedness program should be directed toward the improvement of industrial conditions. In the final analysis, war is a contest between the industries of the belligerents. Therefore, a country whose resources are exploited, whose industries and commerce are well developed, and whose systems of business, education and research have reached a high plane of efficiency would be incalculably better off in the case of a long exhausting war than if reliance had been placed on the military equipment alone.

Preparedness means, not only the optimum military and naval forces for repelling the initial onslaughts of the enemy, but also the power to quickly adapt one's self to the changing conditions brought about by war and to render available the latent resources in the shortest period of time.

It is the organization and development of these latent resources that should demand our attention at this time, as much as the preparation of war equipment for immediate use. This form of preparedness can not lead to militarism, for the results attained will be of as much value in time of peace as in time of war. Militarism is the great danger confronting our democracy at the present time, and war is its inevitable result.

To war the course of empire takes its way and the route is: *scaredness—preparedness—assuredness—war,* but a word to the wise is sufficient.

As a nation we are not sufficiently appreciative of the value to industry of research in pure science. In order to credit certain experimentation, we must see a well-established connection between the work in hand and the end sought. A clear and definite series of results pointing toward a certain conclusion must be produced before we are in a mood to consider the possible importance of the investigation.

Few of our manufacturers have realized the significance of a well-equipped research department in connection with their industries. This statement, however, does not apply to the testing laboratory, whose value has long been recognized and has its place in the factory. The expenditure of a certain percentage of the profits for launching investigations into unexplored fields is another matter.

Some of our manufacturers are still con-

tent to make their products like their grandfathers used to make them, as long as the industries pay a reasonable margin of profit.

The story is told of a large paint manufacturing company, where the superintendent had made repeated but unavailing recommendations to the board of directors for the establishment of a research laboratory in connection with the business. They could see no immediate returns accruing from such an expenditure, but finally yielded to the wishes of the superintendent and voted that a research chemist be employed not to exceed $75.00 per month, and that he be instructed to report to the head paint-mixer.

This attitude on the part of manufacturers has undergone a marked change and they are becoming more and more appreciative of the value in dollars and cents of scientific research. Whatever else may be the results of the European war, one thing is certain, and that is the inevitable stimulus to research in the industries. The influence that this division of science is having upon the progress of the war is exemplified on every hand.

A profounder testimony would be difficult to find than where the integrity of the Teutonic powers has been maintained for two years against a world at arms by the utilization of the results of one man's researches on the fixation of atmospheric nitrogen. Numerous other elements have, of course, contributed, but if nitric acid could not have been obtained in such enormous quantities, the war would probably have been at an end long before this. The latest developments of the Haber process will probably not be known outside of Germany until after the war, and it seems to me that this is one of the more important fields for research in this country at the present time. Why spend millions of dollars upon plants designed to employ an antiquated process, when it is known that other countries are now using a more efficient one? The temper of the American people is such that millions can be had for defense along known lines, but only a meager sum for research.

Almost every industry presents well-nigh infinite possibilities for improvement. The *ne plus ultra* of to-day will be scrapped to-morrow. What is required is an enterprising leader who dares to venture out into the woods on either side of the beaten path of factory routine.

The force of this statement becomes apparent the moment we awake from our lethargic sleep and begin to look about us. We find that the leaders in the industries are those who maintain research departments, for in that way they are able to keep ahead of their competitors by either supplying superior articles at equal cost or as good articles at less cost. Germany's dominating world industry in dye products has been built upon chemical research, its scientific instrument industry upon physical research. The perfume, drug and wine industries of France have been founded upon years of painstaking research.

Our own world industries of manufactured articles, such as photographic goods, oil and packing house products, machinery, steel products, electrical appliances, etc., all take root in research departments, and it is no chance coincidence that the industries supporting the most extensive research departments are those in the highest stages of development.

Now it is financially impossible for the vast majority of our industries to maintain research departments. They are as incapable of aiding their industries in this way as the individual farmers of the country would be in acquiring single handed the latest developments in agriculture as

worked out in the various agricultural experiment stations. Efficiency points to centralization and coordination.

The government has stepped in and aided the farmer where he was unable to get the results alone, but the government has not yet deemed it prudent to intervene in behalf of the small manufacturing industries so as to improve their products and put them on a higher plane of efficiency. This could be done by the establishment of a large government institution for chemical and physical research, with departments at least as numerous as the different industries to be aided.

Instead of the industries being helped by the government, they are actually hindered to a certain extent, especially in so far as unsatisfactory patent laws act prejudically against them. The vast majority of researches carried out in the universities are of such a nature that they have no bearing whatever upon present-day industries, and the essential results obtained in private research laboratories are kept secret so that the small manufacturer will ultimately be forced to the wall, unless he can surreptitiously acquire the processes of his wealthier rival.

Discovery is the aim of research even as it is the aim of all forms of experimentation. Discovery and invention may result upon the most superficial tests which in no sense could be classed as research. In fact, many important and far-reaching discoveries have been made as results of the crudest form of experimentation, but these are the singular exceptions. The rule is, that any important scientific or industrial advance has been made at the expense of years of experimentation and research along that line, coupled with the knowledge derived from countless other lines of work. One industry dovetails into another like the walls of a house and one science blends into another so that it is no longer possible to draw the dividing line.

Even as the sciences are developed by the contributions of thousands of workers, so each industry must depend for its advancement upon the labors and researches of a large number. What an enormous amount of research along many lines must have been carried out to bring the photographic industry to its present high plane of perfection! From the time that Scheele, Niépce and Daguerre made systematic studies of the actinic properties of silver salts, there has been an uninterrupted search for the hidden treasures in this field. The researches have extended into actinometry, organic and inorganic chemistry, colloid chemistry, electro chemistry, radioactivity, gelatine, glass, optics, heat, metal plating, mechanics, etc. No man is the discoverer or inventor of modern photography.

The men who do the pioneer work are usually railed at by the populace as impractical dreamers and scarcely ever live to see the full fruition of their labors. If Daguerre could have had a vision of the tremendous industry that has been reared upon the meager results of his research or if Clerk Maxwell and Hertz could have realized that their theoretical deductions furnished the basis for wireless correspondence across oceans, they could have met the attacks of their critics with a complacent smile. As an example of one man's contribution to industry, Pasteur is perhaps the most illustrious.

His thoroughgoing researches discovered the cause and pointed out the remedy for the souring and spoiling of beer, wine and fruit juices, and thus benefited France and other countries to the extent of millions of dollars. He also saved the French silk industry from certain destruction by the pébrine disease of the silkworm. He dis-

covered the cause and cure for rabies and anthrax, but greatest of all established the germ theory of disease and laid the foundation for serum therapy, an incalculable contribution to humanity. In commemoration of this notable work, his disciples will drink pasteurized milk for generations to come. Pasteur had his critics, too, even as formidable ones as the great German chemist Liebig who once wrote:

> As to the opinion which explains putrefaction of animal substances by the presence of microscopic germs, it may be compared to that of a child who would explain the rapidity of the Rhine current by attributing it to the violent movement of the numerous mill wheels of Mayence.

When the criticisms of thoroughgoing research come from the outside, they are not serious and vital, for time and subsequent work will establish the facts, but when criticisms come from the inside, from untrained officials in charge of the work, then it is they become serious.

What a mass of promising research work has been ruthlessly beheaded by conscientious superintendents, and directors in the name of "practical" results!

How can we distinguish between practical and theoretical research? What appears to the superintendent as being of no value whatever may have the germ of enormous practical returns in it, while the "practical" work he decides upon has such an immediate and superficial character that no appreciable gain, either for science or for the industry, will be made. This question of "practical research" is vital to the welfare of the American industries and should be given thoughtful consideration.

Neither science nor industry can make material advance until the basic laws and fundamental principles governing the same are understood, and the prime object of scientific research is to discover and verify these basic laws, while the purpose of a testing laboratory is to apply the laws already known to definite projects and industries.

What meager advance our electro-chemical industries could have made if it had not been for the discovery of the underlying principles by Faraday, Van't Hoff and Arrhenius.

Modern explosives owe their terribleness to the work of Sobrero, Pelouze, Eder, Schischkoff and Nobel. The soap industry is largely indebted to the painstaking researches of Chevreul; and the dye industry to Perkin, Hoffman, Fischer, Louth and Beyer.

Radium therapy was made possible by the discoveries of Mme. Curie and the multifarious applications of the X-ray rest upon the work of Crooks and Röntgen. The theoretical researches of De Vries and Pfeffer were of inestimable value to Burbank's plant-breeding experiments. Likewise, the "impractical" discoveries of certain rare gases in the atmosphere by Lord Rayleigh and Sir William Ramsay have now been made use of in the manufacture of the most powerful and economical incandescent lamps.

In this day and age no sane person would dare to say that a certain piece of fundamental research will be of no practical value for a hundred years to come. In a few years it might mean the cornerstone of an industry or a science.

At this time and in this connection, it might be well for us to ponder the words of the great French chemist, Dumas, when, in a speech delivered immediately after the close of the Franco-Prussian war, he said:

> The future belongs to science; woe to the nations who close their eyes to this fact. Let us call to our aid on this neutral and pacific ground of natural philosophy, where defeats cost neither blood nor tears, those hearts which are moved by their country's grandeur; it is by the exaltation of science that France will recover her prestige.

C. ALFRED JACOBSON
UNIVERSITY OF NEVADA

SCIENTIFIC NOTES AND NEWS

The fifty-third meeting of the American Chemical Society and the second National Exposition of Chemical Industries are being held in New York City this week. The address of the president, Dr. Charles H. Herty, of the University of North Carolina, was on "Expanding Relations of Chemistry in America." This address we hope to have the privilege of printing in Science, and the official abstracts of papers presented before the divisions of the society will, as usual, be printed here.

In the presence of Secretary Daniels and with appropriate ceremonies twenty members of the Civilian Navy Consulting Board, headed by Thomas A. Edison, took the oath of allegiance to the United States on September 19, as officers of the federal government. They were later entertained at a luncheon at the Army and Navy Club by Secretary Daniels. At the subsequent meeting the industrial survey of the country and the naval research laboratory were among the questions discussed. Those present besides Mr. Edison were Messrs. M. R. Hutchinson, W. R. Whitney, L. H. Baekeland, Frank J. Sprague, R. S. Woodward, Arthur G. Webster, A. M. Hunt, Spencer Miller, William Leroy Emmet, Matthew B. Sellers, Hudson Maxim, P. C. Hewitt, Thomas Robins, Howard E. Coffin, Andrew L. Riker, Elmer A. Sperry, W. L. Saunders, Lawrence Addicks and Bion J. Arnold.

The American Fisheries Society will hold its forty-sixth annual meeting in New Orleans, La., on October 16 to 19, inclusive. As this is the first meeting of the society to be held in any of the Gulf states, special consideration will be given to the problems and conditions of fisheries and fish culture in these states. Professor Jacob Reighard, of the University of Michigan, is president of the society.

Dr. Charles W. Pilgrim, superintendent of the Hudson River State Hospital, Poughkeepsie, N. Y., has been appointed by Governor Whitman to serve as president of the New York State Lunacy Board. Dr. James V. May, former head of the board, resigned some time ago to accept a similar position in the state of Massachusetts.

Dr. Alexander Johnson, for thirteen years secretary of the National Conference of Charities and Correction, has been selected as the expert for the Colorado State Survey Commission to investigate and make recommendations concerning the care of mental defectives and insane in the state, and the charities and corrections departments of the state.

Professor E. M. Lehnerts, of the department of geography of the University of Minnesota, has succeeded D. Lange as president of the Minnesota Forestry Association.

Dr. William H. Welch, of the Johns Hopkins University, sailed from England on September 20. Dr. Welch left for England five weeks ago to obtain data in connection with the organization of the Institute of Hygiene, which was made possible through a gift from the Rockefeller Foundation.

Dr. F. J. H. Merrill, from 1899 until 1904 state geologist of New York, has moved to Los Angeles, where he will resume consultant practise in geology and mining engineering.

For the academic year 1916–17, an exchange has been arranged between Professor Cassius J. Keyser, of the department of mathematics of Columbia University, and Professor Mellen W. Haskell, of the department of mathematics of the University of California.

Dr. M. C. Tanquary, assistant professor of entomology, Kansas State Agricultural College, who was granted a leave of absence in 1913 to accompany the Crocker Land Expedition, has returned to the Kansas Agricultural College and will continue his work in the college and experiment station.

Dr. Donald Reddick, professor of plant pathology, Cornell University, and chairman of the editorial board of *Phytopathology*, has been granted sabbatic leave and will spend the ensuing academic year in special work in the laboratory of plant physiology, Johns Hopkins University. Matters pertaining to *Phytopathology* should be addressed to him at Baltimore until June 1, 1917.

PROFESSOR H. MAXWELL LEFROY has been on special duty with the British army in Mesopotamia connected with fly investigations.

THE John B. Murphy Memorial Association has been incorporated in Illinois by Drs. William A. Evans, James E. Keefe, Allan B. Kanavel, Frank H. Martin and Frank Crozier. It is planned to raise half a million dollars for a memorial to the distinguished surgeon. The two requisites of the memorial are said to be that it be permanent and that it be a "living power making for the advancement of surgery on both the scientific and moral sides."

LEROY CLARK COOLEY, emeritus professor of physics in Vassar College, where he was head of the department from 1874 to 1907, died on September 20, at the age of eighty-three years.

JOSEPH HOEING KASTLE, director of the experiment station of the University of Kentucky, died in Lexington, Ky., on September 23, aged fifty-three years. Dr. Kastle became chief of the division of chemistry in the hygienic laboratory of the United States Health and Marine Service in 1905 and remained in that position until 1909, when he accepted a call as professor of chemistry at the University of Virginia.

SIR T. LAUDER BRUNTON, F.R.S., distinguished for his work in pharmacology and therapeutics, died September 16, at the age of seventy-two years.

DR. ENRIQUE NUNEZY PALOMINA, secretary of sanitation in the government of Cuba, and professor of medicine in the University of Havana, died in New York on September 15, aged forty-four years.

A. F. EMINSON has been killed in action while serving with the British army. Mr. Eminson had recently carried out some valuable investigations into the bionomics of *Glossina morsitans* in northern Rhodesia.

DR. W. ZURHELLEN, assistant at the Royal Observatory, Berlin, died on July 15, aged thirty-six years. It is noted in the *Observatory* that Dr. Zurhellen was one of the members of the Eclipse Expedition from the Berlin Observatory to the Crimea to observe the total eclipse of 1914, August 21. The last news which we had obtained of this expedition was that Zurhellen, being of military age, had been interned in Russia, whilst the older members of the expedition were allowed to return to Germany. After a year in Russia, Zurhellen was allowed to return to Germany; he joined the Bonn contingent, and was killed in the fighting in north France.

THE *Electrical World* quotes from an article in the *Electrician,* by F. G. Donnan, in which he urges a separate department of state to be called the "Ministry of Science." Some of the functions of this department are to establish national laboratories and "bureaus" for the purpose of undertaking extensive investigations; to guide the domestic and foreign policy of the cabinet by having ready at a moment's notice complete and detailed information concerning every question relating to science; to foster, endow and promote the teaching and investigation of science in the universities of the country by giving much larger grants of money to the scientific laboratories. The establishment of a great national bank is also suggested, whose special concern would be the fostering of new and old industries based on scientific method and scientific research.

THE United States Senate on August 29 ratified the treaty with Canada extending to all migratory birds the same protection on both sides of the Canadian border. The American Game Protective and Propagating Association, of which Mr. Edward F. Quarles is vice-president, drew up the provisions for that treaty, recommended them to congress and urged them in Canada. According to the New York *Sun* Mr. Quarles said that the regulations approved by the Canadian government provide for exactly the same degree of protection for migratory birds that is insured to them within the borders of the United States. By the act of congress, approved March 4, 1913, all migratory birds—wild geese, wild swans, wild ducks, snipe, woodcock, rail and all other migratory game and insectivorous birds—which, as the act reads, in their northern migrations pass through or do not remain per-

manently within the borders of any state or territory, shall be deemed to be within the custody and protection of the government of the United States and shall not be destroyed or taken contrary to regulations provided for by that government. The act which was passed in 1913 has been amended and the regulations drawn up by the Department of Agriculture for the enactment of the provisions went into final effect on August 21, 1916, when President Wilson publicly proclaimed the regulation. According to Mr. Quarles, the treaty will secure protection all over the North American continent for some 1,022 species and sub-species of birds, and the law is of prime importance to farmers, for it means that insectivorous birds will get the protection they deserve. All migratory birds, game and insectivorous, will be completely protected in the spring flights, during the breeding season, and the open season on the winter migration south will be curtailed in a great many species. The rulings as to open and closed season in each state have been made with due regard to the state's relative position in the great sweep of migration, north and south, and with provisions for the special protection of certain species in those localities where they have suffered under the old law, or where the farmer needs, for example, the presence of certain insectivorous birds.

The following series of Saturday afternoon lectures are being given in the Museum building of the New York Botanical Garden, at four o'clock:

September 2—"Plants of the Danish Islands, St. Croix, St. Thomas and St. John," by Dr. N. L. Britton.

September 9—"Across Mexico from Vera Cruz to Colima," by Dr. W. A. Murrill.

September 16—"Farming in the Middle West," by Dr. G. C. Fisher.

September 23—"Through the Mountains of Utah and Colorado," by Dr. F. W. Pennell.

September 30—"Flowers for Fall Planting," by G. V. Nash.

October 7—"Botanical Cruises in the Bahamas," by Dr. M. A. Howe.

October 14—"Destructive Fungi," by Dr. F. J. Seaver.

October 21—"Autumn Coloration," by Dr. A. B. Stout.

October 28—"The Potato Family," by Dr. H. H. Rusby.

November 4—"The New York Botanical Garden," by Dr. Britton.

November 11—"Planning Next Year's Flower Garden," by Mr. Nash.

The value of tar, ammonia and benzol products recovered in the manufacture of artificial gas in municipal plants and at by-product coke ovens in 1915 was nearly $25,000,000. Statistics recently compiled by C. E. Lesher, of the United States Geological Survey, Department of the Interior, show that more than 51,340,000 gallons of tar were obtained in connection with the manufacture of oil and water gas, that nearly 48,000,000 gallons of tar was recovered at coal-gas plants, 138,400,000 gallons of tar was obtained in connection with the manufacture of by-product coke, and that the total quantity of tar produced in the United States in 1915 was more than 237,400,000 gallons, valued at $6,260,000. The oil and water gas tar had an average value of 2.2 cents a gallon, the coal-gas tar a value of 2.03 cents a gallon and the by-product tar a value of 2.6 cents a gallon. Approximately 50,700 tons of ammonium sulphate was obtained from the coal-gas plants and about 197,000 tons from by-product coke plants, a total of about 198,000 tons. The value of this ammonia was more than $11,175,000. The coal-gas plants produced and sold 336,213 gallons of benzol, drip oil and holder oil, valued at $28,281, an average value of 8.4 cents a gallon. Benzol products recovered in connection with the manufacture of by-product coke amounted to 16,600,857 gallons, valued at $7,337,371, an average of 44.2 cents a gallon. It is thus seen that coal-gas plants are negligible as a source of supply of benzol products. Nearly 223,000 pounds of naphthalene, valued at $3,565, was obtained and sold from the coal-gas plants as compared with 465,865 pounds, valued at $46,959, from the by-product plants. More than 27,000 tons of retort carbon, valued at $183,170, an average of $6.73 a ton was obtained from the oil and water-gas plants and 1,696,366 tons of gas coke, valued at $7,222,744, or

an average of $4.25 a ton, was obtained and sold from the coal-gas plants in 1915. Including by-product, the output of which in 1915 was 14,072,895 tons, valued at $48,558,325, the coke and retort carbon produced in the United States was 15,796,461 tons, valued at $55,964,239. The value of the tar, ammonia, benzol products, naphthalene and coke produced in the United States in 1915 was $80,816,975.

THE *Electrical World* notes that the great scarcity of potash has almost crippled many of the industries in this country, notable among others being the glass industry. The glass used in making incandescent electric lamp bulbs is a very special kind that must withstand sudden changes of temperature and also great pressure. Heretofore it has been thought that only glass made with a certain amount of potash was suitable for the lamp industry. The outbreak of the war two years ago cut off all supply of potash from Germany and threatened the supply of glass. The research chemists of the General Electric Company, however, succeeded in producing a glass for making incandescent electric lamp bulbs by replacing potash with soda in the glass mixture. This glass, it has been stated, has proved superior to the old potash glass; so much so, indeed, that from now on potash glass will no longer be used. The world supply of potash comes almost entirely from Stassfurt in Germany, because the natural deposits there have been cheaper to work than any other known source. The sources of supply in the United States have proved utterly inadequate to meet the great demand of the industries. Soda, on the other hand, is produced from ordinary table salt, great natural deposits of which are to be found in different parts of the country.

UNIVERSITY AND EDUCATIONAL NEWS

DR. THOMAS F. HOLGATE, professor of mathematics in Northwestern University and dean of the college of liberal arts, has been elected by the trustees *ad interim* president of the university, on the recommendation of the council of deans.

DR. JAMES R. CLEMENS has been elected dean of the John A. Creighton Medical College, Omaha.

DR. A. I. RINGER, formerly assistant professor of physiological chemistry at the University of Pennsylvania, has been appointed professor of clinical medicine (diseases of metabolism) at the Fordham University School of Medicine, New York.

DR. LEON F. SHACKELL, of Washington University, has been appointed an instructor in physiology at the University of Utah Medical School, Salt Lake City.

DONALD W. DAVIS, Ph.D., of De Pauw University, has been appointed professor of biology in the College of William and Mary, and is succeeded at De Pauw University by Hardin R. Glascock.

AT the State University of Iowa, George Bain Jenkins has been appointed professor of anatomy, and Vive Hall Young, assistant professor of botany.

DISCUSSION AND CORRESPONDENCE

THE SONG OF FOWLER'S TOAD (BUFO FOWLERI)

VARIOUS observers have described the voice of Fowler's toad. All descriptions indicate that only its characteristic, weird, droning scream has been heard.

Allen, speaking of the common toad in New Hampshire, believed that the toad's song changed from a prolonged trill to the weird note produced by Fowler's toad. He says:

> After the breeding season the toad's song changes from a prolonged pipe to a shorter, lower-toned note that, at night, has a peculiar wierdness and almost reaches a wail.[1]

Until recently the writer was convinced that Fowler's toad possessed but one song, the unmistakable, weird, wailing scream which advertises its presence throughout its range. It is now known that some individuals produce a

[1] Allen, Grover M., "Notes on the Reptiles and Amphibians of Intervale, New Hampshire," *Proc. of the Boston Soc. of Nat. Hist.*, Vol. 29, No. 3, 1899, p. 71.

prolonged trill resembling the characteristic song of the common toad.

While living at Clarendon, Va., near Vinson Station, the writer every spring has heard the steady, trilling monotone of a toad which he believed to be the common toad, *Bufo americanus*. These notes were among the first batrachian voices to be noted in springtime and were uttered more or less intermittently throughout the greater part of May. On May 2, 1916, the writer established the identity of the toad producing these trilling notes. Several[2] of these toads were captured in the filthy stream just north of Steele's Barn, near Vinson Station; others were captured in the stagnant pools along Fort Avenue, near Maple Street. These toads produced the steady, trilling monotone resembling the song of *Bufo americanus* as it is heard in New England. Although the trill of *Bufo americanus* sometimes continues for 30 seconds or longer, the trill of the toads captured near Vinson Station lasts only from 10 to 20 seconds. Although very variable in size, markings and general coloration, these toads are unquestionably Fowler's toads and can not be distinguished from individuals producing the typical, droning scream which lasts only for 2 to 3 seconds. Individuals producing these notes were captured at the same time and in the same localities.

The iris of both forms is bronze. Although Miller and Chapin[3] are of the opinion that the iris of *Bufo americanus* is bronze and the iris of *Bufo fowleri* is silvery in color, it is evident that such distinctions can not be relied upon in the diagnosis of the two toads.

It is hard to explain why some individuals of *Bufo fowleri* produce a steady, trilling note while others produce a brief, droning scream. These vocal differences, however, are in some manner correlated with fundamental differences of physiology and habit, since the trilling form is first to appear in spring and is rarely heard when the typical mating song of *Bufo fowleri* begins. In 1915, the brief, droning scream of *Bufo fowleri* was not heard at Clarendon, Va., until May 2. The trilling form is always heard early in April, several weeks before this period. After May 15 the trilling form is rarely heard, while the form with the brief, droning scream is heard until August.

The range of Fowler's toad has yet to be clearly established. The writer found this toad extremely common at Thompson's Mills, in northern Georgia. Whether or not this toad occurs in the Coastal Plain region of this state, or extends its range into the Gulf States, is not known. The westward distribution of Fowler's toad has also to be determined. Nothing definite is known concerning the relationship of this toad to *Bufo americanus* in the north, or to *Bufo lentiginosus* in the south.

H. A. Allard

Washington, D. C.

[2] These toads are now in the collection of the U. S. National Museum under accession number 59692.

[3] Miller, W. De W., and Chapin, James, "The Frogs of the Northeastern United States," Science, N. S., Vol. 32, No. 818, September 2, 1910.

BETTER COORDINATION OF UNDERGRADUATE COURSES

To the Editor of Science: A questionnaire recently circulated among alumni by the University of Minnesota (J. B. Johnson, dean), includes a call for suggestions as to the better preparation of students for public service. As the following proposal is not really limited to that application, but appears to be of a character to which the columns of Science have been open, I respectfully submit it for publication or other disposition as may to you seem fit:

Provide, in undergraduate courses and even at great expense, for *"laboratory" use* of that modern language elected by any group of students carrying at the same time (say) French or German and (say) physics, chemistry, animal biology, or history of European diplomacy.

When in college, the undersigned was not alone in wishing that the assistants in charge of laboratory hours would give their directions in, *e. g., French*—resorting to English only as might be rendered necessary by a student's failure otherwise to comprehend. The carrying out of this proposal would of course re-

quire that pamphlets of laboratory instructions be in general published in *three languages,* and it would appear that the most advantageous plan would be to use a *three-column page* —with a polyglot repetition of all material always before each student. This program (as to the absolute novelty of which no adequate investigation has been made) would at least soon enable the men to *use* one selected foreign language for scientific purposes, and it would at the same time invite a cursory acquaintance with another.

Those students taking, *e. g.,* French and physics, would, of course, on this basis, meet for laboratory work in physics separately from those taking German and physics; but the plan would seem worthy of trial even if it were found impracticable to hire as laboratory assistants in all the respective sciences mainly men capable of fluently speaking French or German. The plan could of course be introduced in an experimental way in connection with but one science and but one of the modern languages.

BERT RUSSELL

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SYLVESTER AND CAYLEY

ON page 484 of the third edition of Ball's "Short Account of the History of Mathematics" occurs the sentence:

> He [Sylvester] too was educated at Cambridge, and while there formed a life-long friendship with Cayley.

The two words "while there" seem inadvertently to have slipped in. Without them, Ball's sentence states two facts. With them, it seems capable of the paraphrase,

> Cayley and Sylvester were students at Cambridge at the same time and formed then a lifelong friendship.

Both of these statements are errors, and readily proved erroneous. Thus in the *Proceedings of the Royal Society,* May 9, 1898, page xii, we read:

> In 1831, at the age of seventeen, Sylvester was entered at St. John's College, Cambridge. He came out first in his first year.

In the same *Proceedings,* July 13, 1895, page ii, we read of Cayley:

> Accordingly, he went to Cambridge. He was entered at Trinity College on 2d May, 1838, as a pensioner, and began residence in the succeeding October at the unusually early age of seventeen.

He thus entered Cambridge at the same age as Sylvester, seventeen, but seven long years after him, and Sylvester had previously departed forever, never again to reside in Cambridge.

In the *Proceedings of the Royal Society,* Vol. LXIII., No. 393, page xii, we read of Sylvester:

> He pursued his studies till January, 1837, when he came out Second Wrangler. Being unwilling to sign the Thirty-nine Articles, he was unable to take a degree, to obtain a Fellowship, or to compete for one of the Smith's prizes. On the death of Dr. Ritchie in the same year he became a candidate for the Chair of Natural Philosophy in the London University College. He was appointed to the Chair at University College in the session 1837–38. He had some difficulty in drawing diagrams on the black-board to illustrate his lectures.

Sylvester left London for America to accept a professorship in the University of Virginia, but in 1844, when the foundations of the theory of invariants had been laid by Boole, Sylvester was back in London. For years he resided at 28 Lincoln's Inn Fields.

In the *Proceedings,* LVIII., No. 347, p. vi, we read of Cayley:

> He was unwilling to take holy orders. In consequence, it became necessary to choose some profession. Cayley selected the law, left Cambridge in 1846, entered at Lincoln's Inn.

And on page viii:

> It can hardly be that 2, Stone Court, proved an inspiration to mathematical research.

Thus separately thrown upon the rocky courts of the law, and by the same cause, the religious disbarments of Cambridge, the two were brought together. The biography in Sylvester's Collected Works feelingly refers to their fateful meeting. The ensuing union of their congenial and complementary minds endured without break.

Sylvester presented the first of Cayley's series of Royal Society Papers, and, inversely, Sylvester told me that if he wanted to know anything, he asked Cayley. In the *Proceed-*

ings, LVIII., No. 347, page viii, Forsyth says:

I have heard Cayley describe how Sylvester and he walked round the courts of Lincoln's Inn discussing the theory of invariants and covariants.

Sylvester told me that the only time he ever saw the placid Cayley beside himself was when in the midst of a discussion on the theory of forms a fat bundle of legal papers was brought in to him. Cayley dashed the plethoric bundle on the floor in an access of chagrin.

Thus London was the birthplace of this unique friendship, not the Cambridge which, before ever the gentle Cayley came, had sent out Sylvester without even a degree.

George Bruce Halsted

Greeley, Colo.

SCIENTIFIC BOOKS

A Laboratory and Text-book of Embryology. By Charles W. Prentiss, A.M., Ph.D., Professor of Microscopic Anatomy in the Northwestern University Medical School, Chicago. Octavo of 400 pages with 368 illustrations, many of them in colors. Philadelphia and London, W. B. Saunders Company.

In this new manual of embryology an effort has been made, as stated in the preface, "to combine brief descriptions of the vertebrate embryos which are studied in the laboratory with an account of human embryology adapted especially to the medical student."

The subject-matter of the book, following an introduction, is divided into twelve chapters. The introduction presents the scope of human embryology, emphasizes its importance to the medical student and includes a résumé of the history of the science and a brief statement of the principles of growth and differentiation of the embryo. After a discussion of the methods of study, in which the dissection of embryos as a class-room practise is strongly recommended, this section of the book is concluded by a short list of carefully selected titles of journals and other works of reference dealing with embryology. Chapter I. is devoted mainly to a review of those fundamental facts which are usually learned by the student in connection with the biological studies of his premedical preparation. The description of the human ovum, which is too brief, and the good account of the morphology and developmental cycle of the human spermatozoon should have formed part of one of the later chapters dealing specially with the human embryo. The reviews of the subjects of cell division, maturation, fertilization and the questions concerning heredity, sex determination and twinning may be amplified, if the student so desires, by consulting a number of original sources and well-known books, to which he is referred by citations in the text. In Chapter II. the topics of segmentation and the origin of the germ layers are treated from a comparative embryological standpoint, amphioxus, lizard, chick, bat and rabbit serving as representative types. The study of chick embryos is the subject of the third chapter. Here the text and figures are adapted to work in the laboratory. Directions are given for the preparation of specimens for study; descriptions of whole embryos and sections in three stages of development are presented. Descriptive embryology is resumed in Chapter IV., which discusses the subjects "fetal membranes and early human embryos." Here again the comparative method of exposition is employed with good effect. The main feature of Chapter V., which deals with the structure of small embryos of pig, is the full and careful description of the anatomy of the 10–12 mm. embryo as revealed by study of the surface form, dissections and sections. As this part is adapted primarily for use in the laboratory, the explanation given in the next chapter of the technical methods involved in the preparation of specimens, might better have been included in the present one. The technique of the dissection of embryos evolved in the Harvard Medical School for class practise is described in detail. In the same chapter (VI.) this method is advocated in the study of the face, palate, tongue, salivary glands and teeth. The remaining five chapters (VII.–XII.), comprising more than half of the book, are an account of the development of the organs and organic systems which the student may consult in connection with the more strictly laboratory work represented by

preceding chapters. The subject-matter is divided as follows: Chapter VII., entodermal canal; Chapter VIII., urogenital system; Chapter IX., vascular system; Chapter X., histogenesis, skin and muscles; Chapter XI., central nervous system; Chapter XII., peripheral nervous system. Ductless glands are described in Chapters VII., IX., XI.

It will be seen from this statement of the contents of the book that the subject-matter of embryology is broadly represented. The treatment of topics is in general proportioned to their importance in the understanding of embryology, as means for scientific training and practical application. Descriptions are in the main concise and clear. If we should classify the book on the basis of material used in the text and figures it would be a "mammalian embryology"; yet in order to meet the requirements of the medical student of to-day, examples of developmental processes from lower forms are necessarily brought forward. The directions for class-room dissection is a most commendable addition to a laboratory book on embryology since it will encourage the adoption of this valuable method. While the subject of histogenesis is extensively discussed in text-books of histology it has not had a conspicuous place in the works on embryology which are in common use among medical students; Prentiss's book is an exception to this case and the step taken in devoting a section to the phenomena of differentiation of cells and tissues will be appreciated. Another feature of this work for which the instructor will be grateful is the large number of references to original papers aptly dropped into the text. Incidentally, a review of the names referred to brings out the fact that American embryologists have taken no small part in contributing to the science of development. The book is amply illustrated by figures for the most part well chosen. Many original drawings are included, but the larger number comprises very properly figures taken from original papers. The color work, as a whole, is unusually good.

Mechanical errors are not as common as might be expected in a first edition: a few may be indicated. On page 87, "convexity" is printed evidently for "concavity"; at the bottom of page 234, "scroti" should be italicized to conform with the type of "septum"; the adjective for "tear" is spelled in some places "lachrymal," in others, "lacrymal." The presswork is excellent throughout and the choice of different type for the most part effective and in good taste. One exception might be pointed out: in the selection of type, the use of fine print in Chapter VI. in the description of sections gives the impression of secondary importance to this subject which is unfortunate. Whereas the attention to subjects is in general carefully proportioned, as already stated, there are some instances of inadequate treatment. The discussion of the spleen is too brief and the same is true regarding the origin of leucocytes. Almost nothing is to be found in the book concerning the development of the skeleton. Works on anatomy usually include accounts of the ossification but not of the early developmental processes. Surely a text-book of embryology should present the essential facts of the blastemal and chondrogenous stages of the skeleton. A chapter, or part of a chapter, might have been given over to a consideration of growth and postnatal development in order to emphasize the importance of these subjects which are represented by statements throughout the book in connection with the description of organs. Likewise the subject of histogenesis is not, from a pedagogical standpoint, presented with best effect coupled as it is in the same chapter with subjects quite foreign to it.

If we examine the author's method of treatment of the whole subject of embryology in presenting it to medical students, it is evident that his book fits the peculiar needs of the present time and to some degree points the ways in which the science is growing. Throughout, it inculcates the idea of the incompleteness of our knowledge of embryology and the need of working to gain fuller understanding of developmental phenomena. The text is descriptive of structure primarily, but also largely of the processes of development. More space could profitably have been given to phys-

iological aspects of organs. For example, the questions on the functions of the corpus luteum in the light of many researches, should have generous treatment in our text-books. The same can be said for the results of research in, and for theories on the mechanics of development, experimental embryology and of the field of heredity which is of highest interest to the physician. While these methods and new territories will receive more attention in the future, Prentiss's book probably deals sufficiently with them at this time.

R. J. T.

CONCERNING THE SPECIES AMŒBA PROTEUS

While carrying on some experimental work during the past several years with the larger fresh-water amebas, I became convinced of the existence of considerable confusion concerning the description of *Amœba proteus,* generally regarded as the commonest species of the larger amebas occurring in our fresh waters.

In order to be sure of the exact nature of the organisms I was working on, which is of course essential in experimental work, I decided to look carefully into the matter of species description with the hope of removing, if possible, the confusion I was sure existed here. This work was completed some months ago, but on account of disturbances incident to the great war, the manuscript and drawings reporting the results of this work have apparently missed their intended destination—at any rate their present whereabouts are unknown. Since it is uncertain when the manuscript and drawings will be found again, I have thought that the publication at this time of a brief summary of my findings would be welcomed by other investigators of the larger amebas, who also must have felt the need of a reexamination of the specific characters of *A. proteus.*

Leidy in 1879 described in detail several species of amebas and to one of these species he applied the name *Amœba proteus,* resurrecting Pallas's (1766) old specific name which had been dropped through the influence of Ehrenberg. Leidy described the nucleus of *proteus* as "a thick *discoid* body, with the broad surfaces somewhat convex, flat, or slightly depressed, and the border rounded."[1] Most of his figures show the nucleus a concave discoid.

Penard described *Amœba proteus* as possessing "always an *ovoidal* nucleus."[2]

Now a discoid differs fundamentally from an ovoid. A discoid is a solid generated by revolving a semi-ellipse around its short diameter as an axis, while an ovoid is a solid generated by revolving a semi-ellipse around its long diameter.

Penard's *proteus* is not at all the same species as Leidy's *proteus.*

The question therefore is, Is Leidy's description adequate? It is adequate. All his figures show discoid nuclei, as may be seen by inspection or by reading the descriptions, with one possible exception, perhaps two: Figs. 3 and 4, Plate II. In these two figures the round or polar view of the nuclei is shown. Although these two figures resemble Penard's *proteus* more closely than they resemble Leidy's typical *proteus,* there is not sufficient evidence to enable one to be quite sure of their correct species reference. There can be no question then but that Leidy considered the *proteus* to have typically a discoid nucleus.

Penard described an *A. nitida* with a much folded or crushed-in nucleus and says[3] that Leidy's drawing of the *proteus* nucleus (Fig. 9, Plate II.) "represents so characteristically" the folded nucleus of his *nitida.* But Penard misinterpreted Leidy's figure entirely. Leidy's figure does not show a folded nucleus, but one with a smooth surface, a discoid with slightly concave sides. Moreover, the folded nucleus of Penard's *nitida* I have found represents an old-age stage of the smooth discoid nucleus of Leidy's *proteus.* The ectoplasmic ridges and grooves described by Penard as canals in the endoplasm of *nitida* were also observed by Leidy in *proteus.* Penard's *nitida* represents therefore old (or abnormally large) individ-

[1] "Rhizopods of North America," 1879, p. 41.
[2] "Faune Rhizopodique," 1902, p. 58.
[3] *Loc. cit.,* p. 61.

uals of Leidy's *proteus,* or probably a varietal strain of this species in which the nucleus readily becomes folded. (Penard does not discuss anywhere to my knowledge the fact that Leidy speaks repeatedly of a discoid nucleus in *A. proteus.*)

According to the rules of priority of the International Code, therefore, Leidy's (really Pallas's) name *proteus* must stand for the ameba possessing a discoid nucleus and longitudinal ectoplasmic ridges and grooves on the pseudopods. This leaves Penard's *proteus*—the ameba with an ovoid nucleus—without a name, the name *proteus* having been preempted by Pallas and Leidy. I therefore propose the name *dubia* for this species.

This then clears up the confusion arising out of observations and descriptions relating to *A. proteus* as recorded by Leidy and Penard; but in the progress of my work in this connection some new observations were made which may properly be incorporated in this summary.

To wit: I found that the species *proteus* as Leidy described it may be divided into two species, one of which is larger than the other and always exhibits more or less conspicuous longitudinal ridges and grooves on the pseudopods and frequently shows folds on the nucleus; while the other and smaller species never shows ridges or grooves on the pseudopods nor is the nucleus ever folded. From Leidy's figures and descriptions it is evident that the former species—the one showing ridges and grooves—was considered by him the typical *proteus,* and this name should therefore be retained for this ameba according to the code. For the other species I propose the name *discoides.*

Amœba proteus then is recognized readily by the presence of longitudinal ridges and grooves on the pseudopods. *A. dubia* is easily recognized by the possession of an ovoid nucleus. *A. discoides* is recognized by a discoid nucleus and the absence of folds and grooves on the pseudopods. Any ameba in normal condition belonging to either of these three species may be readily recognized in the living condition under 360 diameters' magnification, according to the characters here enumerated. Of these three species *proteus* and *dubia* are the larger and the more common, while *discoides* is somewhat smaller and less common, so far as my experience goes.

These findings are based on individual pedigrees running for upwards of a hundred generations each for *proteus* and *dubia* and for about forty generations of *discoides,* including always a number of collateral lines. Numerous individuals from wild cultures from various localities were examined and compared with the pedigreed stock. There is much greater permanency in the so-called protoplasmic characters than is commonly realized.

This is a brief and doubtless somewhat unsatisfactory summary of the work on these amebas, but for fuller details and drawings reference must be made to the original paper, which I hope may soon be found and published.

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ZUÑI INOCULATIVE MAGIC

THERE are many varieties of sympathetic magic at Zuñi. I shall give only instances of that subdivision of the homeopathic variety which may be called magical inoculation. It is a form, as it were, of discharming. Instead of applying a bit of the analogous thing to produce an analogy, the direct form of homeopathy, a bit is applied to overcome the analogy, the principle obviously of inoculation.

Birthmarks and malformations are accounted for by the Zuñi as due to parental, for the most part paternal, carelessness during the pregnancy, the result of the expectant father taking part in a ceremonial or hunting rabbits or prairie dogs or other animals or killing a snake. The child will be marked in some way like the ceremonial mask or spotted like a snake or according to the injury suffered by the quarry, blinded or maimed. A medicine member of the Ne'wekwe or Galaxy Fraternity told me that at birth the forehead and chest of his son had had the print of an entrail—preoccupation with the entrails of animals is a characteristic of the Ne'wekwe Fraternity, and this man had in fact taken part in a fra-

ternity ceremonial before the birth of his son. The head of the daughter of this once birth-marked man was a bit flattened on one side. It was flattened, believed her grandfather, because her father would go prairie-dog hunting before her birth and he always shot his prairie-dogs in the head.

Now the cures for birthmarks or malformations are, the cause being a ceremonial, to put on the ceremonial mask in question and dance hard in the presence of the child, subsequently rubbing the sweat of one's body on to the child; and, the cause being a hunted animal, to hunt the same animal and rub its blood on the child. Similarly, to cure an infant of crying incessantly—it cries because its back pains and its back pains because before its birth its father has overdriven his horses, belaying them presumably on the back—to cure it one must drive a team hard and rub on to the child's back the sweat from under their collar or some piece of their harness.

If a child becomes deaf—cases of deafness at birth are unknown—it is because during her pregnancy its mother stole. To cure the child she must steal again and burning the object stolen puts its ashes into the ears of the child. If the cord of a new-born infant "runs," it is because one who has been bitten by a snake has been present in the room. That person should be found and then four times he should wave some ashes around the heads of mother and child. Otherwise the child will die.

The deer-hunter who sees a buck and doe together and the buck mount the doe, knows that by this token the deer are "telling" him of what is happening at home. His faithless wife is far from "staying still" in the house she should leave but once, at noon time, for water, while her husband is off hunting. It becomes his business, therefore, to shoot the deer and take out their hearts. On his return home he will find his wife and her lover sick. To cure them, if he pity them, he will have to rub them with deer heart made up into a ball with meal, rubbing the woman with the heart of the doe, the man with the heart of the buck.

Should a person be struck or shocked by lightning, he or she must be given some rain water of that same storm to drink, rain water plus black beetle and suet. Otherwise the person will "dry up" and die.[1] About three years ago a certain house on the south side of the river was struck. The three women in it neglected to take the prescribed drink. To-day the three are dead, two dying a year or two ago, the third this summer.

Should a person in dying "frighten" any one, from the head of his corpse a lock of hair is cut. The hair is burned and the smoke of it is inhaled by the person who has been upset. This practise, however, is uncommon.[2]

Elsie Clews Parsons

SPECIAL ARTICLES

THE IMPORTANCE OF LATERAL VISION IN ITS RELATION TO ORIENTATION

It is a well-established principle that binocular vision gives to human beings a means of determining the relative distances between near-by objects, as well as the distances of these objects from the observer. The basis of this power lies in seeing the objects from two points of view, giving a stereoscopic effect, which, however, is decreasingly effective as the objects are removed from the eyes. It is apparently partly the decreasing stereoscopic effect with increasing distance which forms the basis of measurement; and partly a judgment of distance in some way through the muscular movements of the eyes, and those governing the accommodation of the lenses. The power of measuring distance by binocular vision is, however, scarcely effective at distances greater than four or five hundred feet. It is entirely

[1] The experience qualifies a survivor for becoming a doctor. One of the present *tenientes* or members of the governor's staff or council is a lightning-struck doctor.

[2] Mrs. Stevenson's description of this practise is somewhat different, remaining, however, one may infer, an illustrative of inoculation magic. "If a person takes a bit of hair of a deceased friend, burns it, and inhales the smoke he will have good health and not die, but go to sleep and thus pass on to Ko'thluwa'la" ("The Zuñi Indians," p. 309, XXIII. (1901–02), *Am. Rep. Bur. Amer. Ethnol.*).

lacking beyond fourteen hundred feet, according to Gleichen.[1]

In the case of a man moving through a forest or any maze-like region, owing to the frontal position of his eyes, the axis of his vision is parallel to his motion; hence the apparent displacement of the trees of the forest as seen by him, due to his forward motion, is a *minimum*. The effect is similar to that when a person is riding on a railway and looking out from a front window of a car straight at the track and its immediate surroundings. It is obvious that relative displacement of objects near the track in the retinal picture due to motion of the observer is very slight. In frontal vision, as in man, a displacement of the head *sidewise* affords a powerful means of measurement of distance, as has been pointed out, probably first by Helmholtz.

The eyes of most birds, fish and reptiles are so situated in the skull that only lateral vision is possible. A number of species of birds, however, have the ability to turn the eyes so as to give binocular vision at will, and some species have two distinct vision foveæ, "yellow spots," in each eye, for distinct sight for the two types of vision. Other species have two of the round and one streak-like foveæ; particularly certain ground-feeding birds of the snipe family, etc.[2] Some of the mammalia have lateral vision, some have their eyes so placed that the retinal pictures partially overlap and binocular vision is possible; others have frontal vision as in man. It is interesting to consider in what manner the lateral position of the organs of vision enters into the determination, for example, by a bird, of the distances of surrounding objects. It is an important question, owing to the intimate connection of such determinations with the "sense of direction" problem.

There seems to be good evidence that those living creatures having side vision have a decided advantage over man in their ability to gauge or measure the relative distances of their surroundings, owing to the lateral position of the eyes. When a bird or a mammal, etc., with its eyes so placed, moves forward, the principal visual axis is *perpendicular to its motion*. This gives the *maximum* apparent displacement of objects with every forward motion of the creature.

This displacement of surrounding objects gives to the animal having lateral vision a means of a continual register of the *relative distances apart* of surrounding objects. To use the analogy of a person riding on a railway, it is as if one was looking out of a side window of a car. There is the additional advantage for the animal, since it may be said to be looking out of two side windows, one on each side. There is, moreover, the possibility, in the case of creatures having lateral vision, of a differential effect, since a change in the direction of the head while in the forward motion would be registered on the retina of each eye. The advantages of lateral vision for measuring the relative distance of surrounding objects is illustrated as follows:

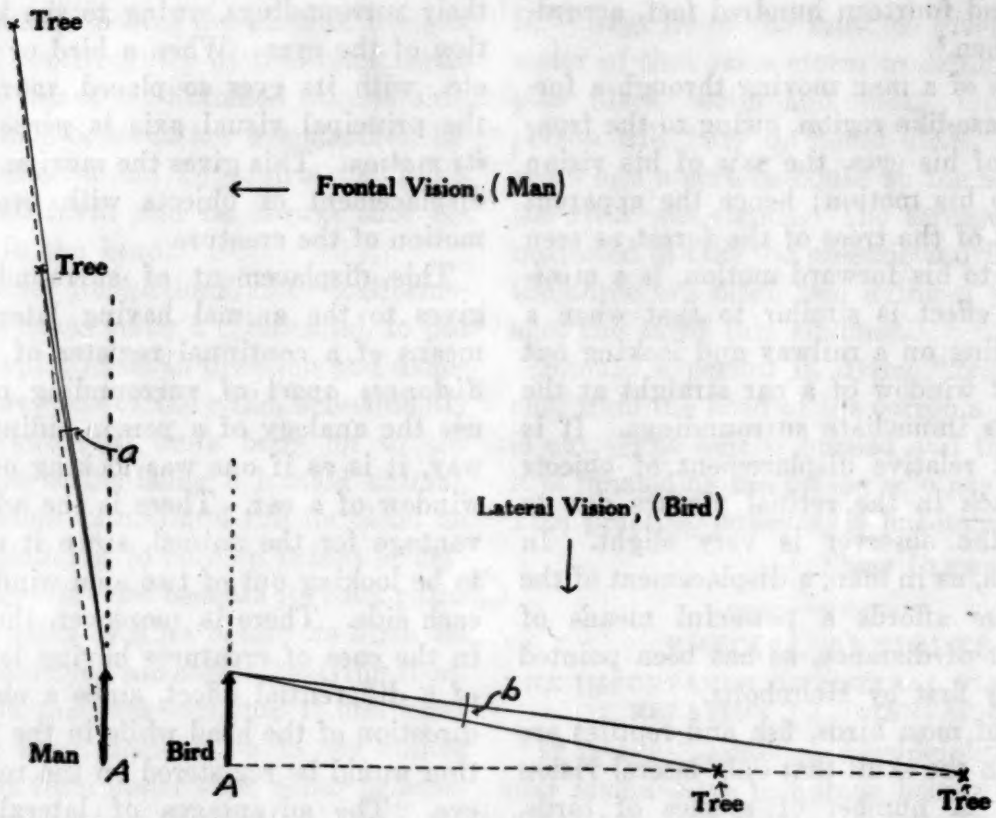
The arrows in Figs. 1 and 2 are meant to represent a man moving forward along a straight path 15 feet, and a bird also moving forward 15 feet respectively. Both observe trees (the crosses) at 100 feet distance from *A*, the starting-point.

The trees are in front, nearly, of the man in the one case, and at the side of the bird in the other. The angles *a* and *b* are the angular measures of apparent displacements in the two cases, due to the forward movements. With the distances given in Figs. 1 and 2, these angular measurements are as 5 is to 1 in favor of the bird, but this is assuming that the man has only one eye. For distances within a few hundred feet of the man, as in Figs. 1 and 2, binocular vision is a means of measurement of distances, and hence the bird's advantage is less than the ratio given. It is, in fact, hardly possible to state a true measure of the advantage.

In Fig. 1 it is necessary to place the trees considerably to one side of the man's path; otherwise there would be no angular displacement of the trees for the man whatever.

[1] A. Gleichen, "Die Theorie der Modernen Optischen Instrumente," p. 184.

[2] "Lehrbuch der Vergleichenden mikroskopischen Anatomie," Part 7, pp. 82–84.



FIGS. 1 and 2. These diagrams show the parallax (displacement) of objects as viewed in frontal vision and in lateral vision. The ratio of *b* to *a*, with distances given in the text, is 5 to 1.

In order to give figures showing the advantage of lateral vision over frontal vision at greater distances due to motions forward, two cases were selected where the objects are two trees, one at 1,000 feet and the other 2,000 feet distant, respectively, from the observer (man and bird), the trees being approximately in the axis of vision in each case. To obtain any values it is necessary (as in Fig. 1) to place the two objects observed (trees) out of line of the direction of the man's motion; that is, to one side of his path. The results in Fig. 3 and Fig. 4 were obtained from a graphical construction which is omitted.

Fig. 3 is an equal parallax curve and it shows the distance that a man and bird must each move forward to give the same apparent displacement of trees against the horizon. In the figure the points are plotted as they were found from the graphical construction, and show a slight irregularity.

Fig. 4 is a curve constructed from Fig. 3, and it illustrates the decided advantage of the bird over the man.

The bird's advantage is obtained by dividing the distance that the man must move forward by the distance that the bird moves forward to obtain *equal displacement of the objects viewed.* For example, at the point *M*, the man has moved forward 20 feet and the bird's advantage is 12 to 1. At point *N* the man has moved forty feet, and the bird's advantage is 10 to 1, etc.

The distances of one thousand and two thousand feet were taken as a basis for the curves in Figs. 3 and 4 because binocular vision is not a means of measurement at these distances, and hence the advantages for the bird are as they have been given in the figures.

This method of demonstrating the advantage of lateral vision serves chiefly to give some numerical expression of the value of that type of vision for the measurement of the distances apart of objects in the field of view.

In conclusion it may be stated then that an animal having only lateral vision, *if at rest,* has no means of measuring the relative distance of surrounding objects, except by comparison of the various size of objects, and

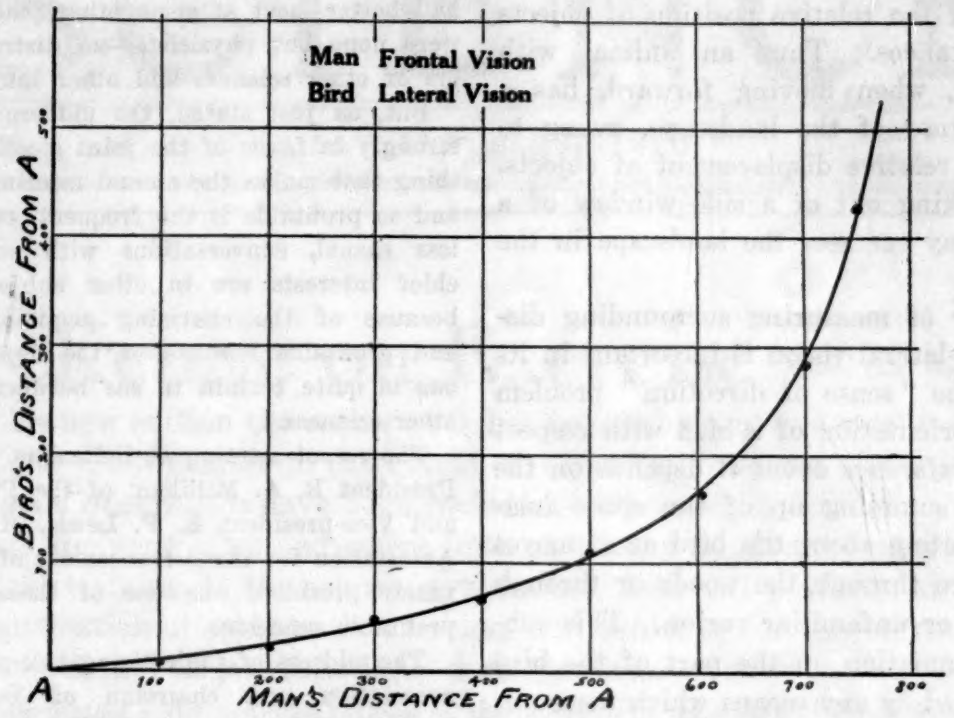


FIG. 3. Equal parallax curve, showing the distances a man and a bird must move forward to give the same apparent displacement of objects against the horizon.

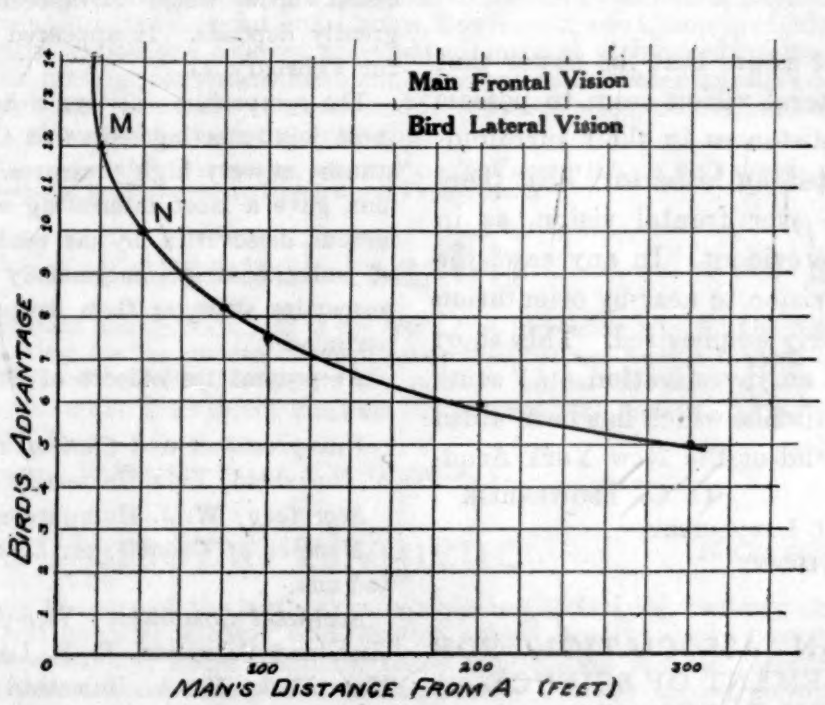


FIG. 4. Advantage curve. The bird's advantage is obtained by dividing the distance that the man must move forward by the distance that the bird moves forward to obtain the same displacement of objects viewed. At *M*, the advantage is 12 to 1; at *N*, 10 to 1, etc.

through accommodation, etc. An animal having binocular vision (man, ape, cat, etc.), *if at rest,* has such a means for the measurement of objects that are not more than a few hundred feet distant.

If creatures having each type of vision are *moving forward,* then there is a distinct advantage in favor of the one having lateral vision. This is especially the case if the objects viewed are in the middle ground (500 to 1,500 feet away), or at greater distances, since binocular vision furnishes little, if any, means

for measuring the relative position of objects at these distances. Thus an animal with lateral vision, when moving forward, has a stereoscopic view of the landscape, owing to the excessive relative displacement of objects. A person looking out of a side window of a moving railway car sees the landscape in the same way.

This power of measuring surrounding distances due to lateral vision is important in its bearing on the "sense of direction" problem because the orientation of a bird with respect to *points of reference about it* depends on the subconscious summing up of the space relations immediately about the bird as it moves here and there through the woods or through any familiar or unfamiliar region. This subconscious summation on the part of the bird is greatly aided by any means which measures the relative distances of minor reference points in its immediate vicinity as it passes on its way.

The writer is not aware that the power that animals having lateral vision seem to possess of measuring the distances in their surroundings has been pointed out hitherto. That there is such advantage over frontal vision, as in man, appears to be evident. In any case, the relation of lateral vision to near-by orientation has not been properly emphasized. This short paper is a part of an investigation on "sense of direction" in animals, which has been aided by the Herman Fund of the New York Academy of Sciences.

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THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE—SECTION B, PHYSICS

The biggest and the best of the several meetings the American Physical Society holds every year is always that one held jointly with Section B of the American Association for the Advancement of Science. There are of course very few active members of this section who are not also active members of the Physical Society and therefore it might seem that there could be no advantage in holding joint meetings. Indeed it might even be argued that the Physical Society had better meet at some other place where there were none but physicists—no distracting reminders of other sciences and other interests.

But, as just stated, the uniform experience is strongly in favor of the joint meetings. And one thing that makes the annual meeting so delightful and so profitable is the frequent, even if more or less casual, conversations with scientists whose chief interests are in other subjects—delightful because of the charming acquaintances formed and profitable because of the new interrelations one is quite certain to see between his own and other sciences.

The recent meeting at Columbus, Ohio, at which President R. A. Millikan, of the Physical Society and Vice-president E. P. Lewis, of the American Association for the Advancement of Science, alternately presided, was one of these pleasant and profitable occasions.

The address of the retiring vice-president of the association and chairman of Section B, Dr. Anthony Zeleny, was a well-deserved tribute to the designer and the maker of instruments of precision upon whom advancement in science so greatly depends. It appeared in full in Science for February 11.

The symposium—always a delightful feature of these joint meetings—was on the behavior of substances at very high pressures. Dr. P. W. Bridgman gave a most interesting summary of the numerous discoveries he has made of the properties of substances at enormously heavy pressures—properties stranger than fiction and of great importance.

At present the officers of Section B are as follows:

Vice-president and Chairman of the Section: H. A. Bumstead, Yale University.

Secretary: W. J. Humphreys, Washington, D. C.

Member of Council: A. L. Foley, University of Indiana.

Sectional Committee: Vice-president, San Francisco and Columbus, E. P. Lewis; Vice-president, New York, H. A. Bumstead; Secretary, W. J. Humphreys; Preceding Secretary, Alfred D. Cole; T. C. Mendenhall, one year; Dayton C. Miller, two years; George W. Stewart, three years; Robert R. Tatnall, four years; W. S. Franklin, five years. *Ex-officio:* R. A. Millikan, President, American Physical Society; Alfred D. Cole, Secretary, American Physical Society.

Member of General Committee: G. B. Pegram, Columbia University.

W. J. Humphreys,
Secretary